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ABSTRACT

This project analyzed the regular patterns of social interaction in science classrooms and the verbal and non-verbal strategies by which the science content of lessons is communicated. Based on observation and recording of 60 lessons by 20 teachers in 3 schools and a university, the project identified: (1) the principal science classroom situation types and the rules of behavior by teachers and students in each of them; (2) principal strategies by which the system of scientific meanings being taught is expressed in the classroom dialogue; (3) the rules observed by teacher and students concerning what is a "proper" way to talk science; and (4) the relations between teachers' observing or breaking those rules and the likelihood of students showing attentiveness to the lesson. Results indicate that: (1) students are three to four times as likely to be especially attentive when rules are broken by the teacher as when they are being followed; (2) most of the time the scientific meanings being taught are expressed implicitly, not explicitly in the classroom dialogue; and (3) social beliefs about science and learning artificially limit classroom dialogue in ways which make it more difficult for most students to learn science. (Author/JN)

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CLASSROOM COMMUNICATION OF SCIENCE

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FINAL REPORT

NSF/RISE: SEDR 79 - 18961

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General Summary

This project analyzes the regular patterns of social interaction in science classrooms and the verbal and nonverbal strategies by which the science content of lessons is communicated. Based on observation and recording of 60 lessons by 20 teachers in three schools and a university, the project has identified: (1) the principal science classroom situation types and the rules of behavior observed by teachers and students in each of them, (2) the principal strategies by which the system of scientific meanings being taught is expressed in the classroom dialogue, (3) the rules observed by teacher and students concerning what is a 'proper' way to talk science, and (4) the relations between teachers' observing or breaking those rules and the likelihood of students showing attentiveness to the lesson. Students are three to four times as likley to be especially attentive when these rules are being broken by the teacher as when they are being followed. Most of the time the scientific meanings being taught are expressed implicitly, not explicitly in the classroom dialogue. Social beliefs about science and learning artificially limit classroom dialog in ways which make it more difficult for most students to learn science.

Preface

This is the final Technical Report for the Project "An Investigation of the Structure and Dynamics of Classroom Communication of Science" funded under the Research in Science Education (RISE) program of the National Science Foundation from September 1979 to April 1982.

This is a very long Report. The interesting patterns in classroom communication of science link the details of classroom discourse and social interaction across often lengthy episodes or even whole lessons. To illustrate them requires line-by-line reference to transcripts and observer fieldnotes.

The analysis of human social systems of action and meaning raises major theoretical questions which would require a book-length treatment of their own. The first three sections of the Prolegomena are no more than an outline of the system of theoretical choices made in this work.

Readers who are not already familiar with the theoretical issues involved may wish to begin with section 4 of the Prolegomena which gives an account of the procedures of the Project.

Chapters 1 and 2 describe in great detail the small number of regular patterns of classroom social interaction and regulation of participant behavior. The end of Chapter 2 gives lengthy analyses of episodes illustrating these processes in action. Chapter 3 describes the most common ways in which the 'science content' of lessons is implicitly carried by the discourse; this is probably the area least explored in previous research. Chapters 4 and 5 describe the norms of 'proper' scientific discourse in the classroom, their violation, and its relations to student communicative engagement with the lesson.

Jay Lemke

CLASSROOM COMMUNICATION OF SCIENCE

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PROLEGOMENA: THEORETICAL FRAMEWORK AND ANALYTICAL METHODS

1.0: Social Systems of Interaction and Meaning

'Prolegomena' means, of course, 'to be read first', and here to be read first because what is said provides an explication, though incomplete, of the general theoretical framework within which all that follows is supposed to be made sense of. But just as we need such a framework within statements, analytical methods, and research procedures, so equally we need to consider the status of the theoretical framework itself if our work is to be honestly self-reflexive and critical. In doing research on human behavior, its systems of relations of actions and their meanings, we are ourselves engaging in such actions and enacting such a system of meanings. What then is the relation of a theory with which we might describe meaningful actions in a classroom and one which might describe the meaningful actions of our own research practices?

1.1: Praxis and the problems of meta-theory

Can a theory of human social systems of action and meaning contain itself in its own domain? Is it possible to have a formal theory which, in providing 'explanatory' accounts accounts of what people in a social system do and say, their practices and theories, in the same sense 'explains' among other things _itself_? Can a theory be its own meta-theory? Since Gödel, we know that _as a formal system_ a theory cannot do so. Formal theories must be recursively incomplete, excluding themselves from their own domains, if they are to remain internally consistent. At first this seems to present a complete impasse for the development of a general theory of human systems, but a shift of perspective can transform it into an invaluable guide for the analysis of just such systems. The impasse can point us away from the narrow notion that formal theories are the goal of science. The goal of science needs to be seen instead as effective scientific practice, all the ongoing activities of its communities, in which formal theories play the role of tools and are not viewed as ends in themselves. Part of our analytical practice can be to subject our own practices to analysis, to become our own meta-analysts, making models of the implicit 'theories' of our practices, in which our explicit formal theories are merely more 'data' to be considered with all the rest. Thus we are engaged in self-reflexive, critical practice - in praxis. Moreover, we are no longer primarily concerned with a fixed and static entity, a formal theory, but with a dynamic, at most meta-stable system of processes, a praxis, and require a correspondingly dynamic view of human social systems generally.

But our praxis is not solely reflexive. We make models of the practices of other communities with which our own interact, including their practices of attributing meaning; explicitly or, seen by us, implicitly to events and actions. In terms of our praxis as analysts, we can neither 'step outside' our own systems of meaning to analyze them, nor leave these behind to get 'inside' those of another community. This seems to pose another impasse, but again can be a guide of great usefulness. Every theory or model is necessarily in this view a 'folk-theory' of some community; no theory can provide a 'universal grid' whose claims to universality are grounded outside the praxis of the community which uses it. But when the analyst-community and another community interact, a hybrid community may be defined, distinct from either 'pre-contact' community, and its practices recursively analyzed to formulate representations of its hybrid meaning systems. In terms of these hybrid meaning systems, we may model the meaning systems and practices of other communities, as well as our own.

A special problem arises, if we consider that part of reflexive praxis entails analyzing the functions of the theories and theoretical assumptions of a social system in that social system, analyzing them in relation to practices that maintain that social system. Applied to our own theories as analysts, this requires that we concern ourselves primarily with how they are used; applied to the 'folk-theories' of other communities with which we interact, either as insiders (our 'home' society) or as outsiders (communities we 'study'), it requires that we concern ourselves with their social functions rather than with their 'truth', and that we be able to analyze them without ourselves adopting these same assumptions. This calls not only for a radical scientific skepticism of even the most 'necessary' axioms of our own cultural traditions, but for the construction of theoretical viewpoints capable of analyzing the social function of those axioms in our society without presuming them. This might seem another paradoxical impasse, except that a praxis-centered view that our very praxis is part of the dynamcis of change of the social systems 'to which we belong', with which we interact. What makes this praxis possible are the very system features and processes that insure that no human social system is completely stable or limited by a meaning system within which it is not possible to formulate that system's limiting functions, and by doing so, contribute to system change. We will return to this dynamics in section 3 below.

1.2 The conceptual framework of sociosemiotics

In the previous section the conceptual framework of sociosemiotic praxis has already been implicit. 'Semiotics' names a system of analytical practices that explicate how 'entities' have meaning thru systems of relationships to one another. Each item or feature has meaning, not in itself, but by virtue of its place in the overall system, its contrasts along various dimensions with other items or features. The term 'sociosemiotics,' like the term 'sociolinguistics' serves to remind us that semiotic systems of meaning are enacted by the practices of members of a social commuity, and that it is not the systems of meaning *per se* or the systems of human interactions that constitute these meaning systems, but their interrelationships. These are the primary focus of our praxis, without which it could not be self-reflexive and critical nor adequate to the analysis of system change. The following paragraphs will develop tho only in outline, what in sec. 2 and after we will call the thematic system of sociosemiotics, its way of talking about human systems of action and meaning.

A human social system is a Sociosemiotic System (SS) when analyzed as a system of social interactions (Interaction System, IS) which constitute or enact a semiotic system of meanings (Meaning System, MS) in terms of which alone the interactions have meaning as activities, events, actions, practices, or entities.

As an Interaction System (IS), a human social system is viewed as a dynamic open system; that is, one which maintains its continuity of existence as a definable system by exchanges of matter, energy, and information with its environment. All biological and many other physical systems are of this kind. They share the special characteristic that they may increase and maintain their internal structural and dynamic order, exporting to the environment the entropy disorder they generate internally in maintaining themselves, and importing order (negentropy) as matter, energy, or information from their environments. Such systems cannot be stable, only at best dynamically metastable, for change arises from the fundamental paradox of their existence as dynamic open systems: in order to maintain themselves they must constantly engage in interactions that change them, interactions with their environments that export disorder to them, changing them in ways that alter the conditions of the very exchanges on which system existence depends, and so requiring system change in response to these consequences of efforts at system maintenance. On resultion of the paradox is the evolution of a hierarchical structure in which the former system/unregulated environment interactions become internal regulatory processes of a larger 'supersystem' into which both are now integrated. Many levels of such a subsystem-supersystem hierarchy may exist with change and instability at each level dynamically coupled to the maintenance of invariances at higher and lower levels. Change is necessary to maintain the invariances that characterize the overall system and constitute its continuity as a system. The overall supersystem of course must still transact with its ultimate environment and needs to avoid a perfect internal regulation which could no longer response adaptively to the effects of the transactions. Some subsystems must always function to disrupt the perfect self-regulation of the supersystem; their internal regulatory interactions will be partially deregulating for the supersystem, thus ensuring it reserve adaptive capability. The flexibility of system response which is needed to permit regulatory mechanisms to maintain critical invariances at the same time provides for degree of freedom that represent potential for system change (cf. Prigogine 1972, 1976). In the hierarchy of invariances of the IS, change at lower levels merely serves to insure invariance overall; but the overall IS also changes.

In a human social system, some physical biological, social systems of interactions will be meaningful, i.e. identified as events, acts, processes, relations, entities, etc. and will be contrasted as having the same or different meanings from one another, within a mostly implicit system of meaning relations we will call its Meaning System (MS). What are counted as the same may also count in other contexts as different, yet the socially chared MS of a community allows most members to make sense of most of what is recognizable as meaningful in events and the actions of others, and make sense to them in turn, in ways that permit social interactions which maintain the system. If meaning is relational in this sense, what kind of architecture for the system of relations we are calling the Meaning System is required to tell which relations obtain between events, actions, utterances, persons, etc., and when? This is the fundamental problem of contextualization: not merely to say that the meaning in each case depends on the context, but to tell what the context in eace case is. But this is not so simple, even in principle. For suppose that some event's meaning is to be defined by its contrast relations in some set of alternatives. Usually it may belong to many such sets, each defined by a different particular meaning relation or kind

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of contrast among its members. Which set, i.e. which sort of meaning relation applies on a given occasion is a function of some other features of that occasion which define the relevent context by which the other features of that occasion which define the relevent context by which the MS specifies that relation, contextualizing the event. There might be a regular system of connections of contexts and meaning relations for an event, but that entire system of connections will not in general be given, fixed, or universal and can have its own meaning only as part of a wider system of such systems of connections, and so the MS must specify which system applies when - i.e. must contextualize the first-order contextualizing relations, relating them to their contexts. This leads to an infinite regress of contextualization. As with other apparent impasses in the development of a consistent sociosemiotic praxis, this too can be viewed as a valuable guide. In a relational theory of meaning not only is contextualization fundamental, but a meta-contextualization hierarchy needs to be constructed as a representation of the MS. It is quite a different kind of hierarchy from the subsystem-supersystem hierarchy of the IS, which is also a kind of 'contextualization' hierarchy in that the supersystem provides the 'context' for possible subsystem-subsystem relations, i.e. interactions.

We can complete the sociosemiotic theory of meaning by specifying a system of formal relations adequate to represent the MS as a metacontextualization hierarchy. It appears that if contextualizing relations are represented formally as (meta-)redundancy relations of at least second order, the entire hierarchy can be represented as a system of higher-order redundancy relations. In brief, what this means is that we begin by representing some meaning relations among 'entities' (which may themselves be relations, but we choose a 'level of first focus' on which we need not consider them such) as a first-order redundancy relation. This means that some entities, A_i, have such a relation with entities B_j if not all possible combinations (A_i, B_j) occur with equal likelihood. Then we can write the relation as (A_i/B_j): 'A is redundant with B.' But the specific connections of the A's and B's may be context-dependent, and this contextualizing relation we represent by the second order redundancy relation $(A_i/B_j//C_k)$, where the C_k are various contexts. Now we have that the C_k are redundant with the redundancy between the A_i and the B_j. In any context C there will be a specific system of connections between the A's and B's. In a different context C_2 there will be a different set of connections. Not only do the relations $(A_i/B_j//C_k)$ contextualize $(A_i//B_j)$ by C_k, but they also show the sense in which the contexts C_k are themselves constituted by the pattern of the A's and B's connections because redundancy relations are symmetrical at each order, i.e. $(A_i/B_j) = (B_j/A_i)$ and $(A_i/B_j//C_k) = (C_k//A_i/B_j)$. The MS is now representable by a structure of the form: (A/B//C//K//// ... Z), up to a high enough order than all variability in the MS is exhausted. In practice four or five orders of contextualization probably exhaust our praxis as analysts.

In sociosemitoics the Meaning System is immanent in the Interaction System; it is by enacting the patterns of connections which define the MS that it is renewed and changed moment to moment and generation to generation. Clearly change which affects the lower-order relations of the MS may not structurally affect the higher levels, though constitutively the whole system is slightly different. Changes at the higher levels correspond to major changes in the architecture of the entire MS. But while we have just emphasized that the IS in enacting the MS is constitutively prior to it, the MS is analytically prior to the IS because it is only in terms of its meaning relations that the IS can be defined or analyzed. It is this dual perspective which enables sociosemiotic praxis to analyze system change: it is the possibility of 'slippage' between MS and IS, along with the subsystems of the MS that are enacted by the necessary counterfunctional deregulatory subsystems of the IS as a dynamic open system, and the hybridization of Meaning Systems when their Interaction Systems interact with one another, that provide the basis for a theory of system change (see section 3 below).

2.0 Analyzing Interactional Structures and Thematic Systems

We turn now to an exposition of the analytic practices used in analyzing the structure of situated social interaction and the thematic systems participants use and develop. The Meaning System enacted in such interactions contextualizes the discourse of action, including speech, writing, movement, etc. in two analytically separable ways. Every event has meaning as part of a 'culturally recognized' (i.e. MS-contextualized) interaction structure, a regular pattern of related actions or events, each of which is 'appropriate' to the interactional situation-type it and other acts constitute by occurring, and it has meaning within a system of semantic relations, occurring appropriately in a thematic context of situation. Thus two classroom lessons may employ very similar activity structures to regulate the interaction of participants, but the thematic systems in use will be very different if one is discussing chemical reactions and the other the colonization of America.

2.1 Thematic and interactional contextualization in classroom discourse

Given this overview of the conceptual framework, it is useful now to explicitly formulate some of the conceptual relations it ties together. The meaning of an utterance or other act depends on a variety of contexts: the utterances and actions that precede and follow it (in written material sometimes called its 'co-text'), but also, as Malinowski (1923) and later Firth (1957) emphasized, its 'context of situation' and 'context of culture'. Taking the latter as equivalent to our general cultural system of meanings, the social semiotic which defines meaning by specifying 'what is to be regarded as contrasting with or redundant with what else, when' (the meta-contextualization hierarchy of Lemke 1977, 1979), it defines *a fortiori* what will be recognized as situation-types in that culture (i.e. for those sharing this meaning system) and the entities and activities by which the type is recognized and through which it is enacted. But for the unitary notion of 'context of situation' we need to put the dual concepts of the interactional situation and the thematic situation, so that every act is assigned a meaning both in the interactional context and in the thematic context and contributes to both interaction and thematic development, having the power to radically alter as well as to maintain both the interactional and the thematic situations.

The interactional situation encompasses all that concerns the mutual regulation and deregulation of social behavior: the physical and information exchanges among the participants, eht entities and acts (*as* acts) that occur, the structuring of the activity by a succession of acts of types regularly related to one another in such a situation, as the culture defines it. Thus when student answers follow teacher questions, social behavior is being regulated within a pattern of interaction characteristic of a culturally recognizable situation type, in which a variety of other situational features (e.g. use of the blackboard, special rights in the allocation of speaking turns, teacher evaluation of student answers, or physical violence) are either expected to co-occur or not to, and it is by the presence of such features, or their absence, that the interactional situation is maintained.

But while a particular interactional situation-type is being maintained, and every act is appropriately 'within bounds' and conforms to some option in the on-going negotiation and manipulation of the status of the interactional situation from act to act, the thematic situation is also being enacted by these same acts. Their thematic meaning defines 'what is being talked about' or 'what is being meant', what the question asks and what the answer answers. A question may be appropriate as a question, sustaining a normal succession of interactional events, but it may ask something 'off the topic', incongruous, or not recognizably meaningful in the previous thematic context. Indeed it may redefine the thematic situation and retroactively alter the meaning previous acts have now.

We are thus led to examine two interdependent, but analytically separable kinds of structure in discourse: the activity structures to which every act belongs by virtue of its contribution to the interactional situation, and the thematic structures constituted by the relations among their purely semantic meanings. For science classroom discourse, regularly recurring activity structures range from the large-scale episode types, such as 'review' and 'demonstration', to the often-cited 'triad structure' of 'teacher-initiation', usually realized by a known-information question, 'pupil-response', typically an answer, and 'teacher-reaction', usually an evaluation of the answer, all realized as single speech acts (cf. Sinclair and Coulthard 1975, Mehan 1979, Griffin and Hymphrey 1978). thematic structures range from the theme of the entire course ('Chemistry'), to that of the current Unit ('Chemical periodicity'), the lesson, etc., on down in scale to the semantic class unity of the elementary 'cohesion chains' (Hasan, forthcoming; Halliday and Hasan, 1976) of lexical items within an utterance and across speaking-turn boundaries. All may occur simultaneously in the speaking of a single lexical item.

Of course thematic and interactional structures are not independent of one another. The general cultural meaning system links them through its norms of the reciprocal appropriateness of some themes and some modes of thematic development (e.g. types of thematic structures, stylistic norms) to certain interactional contexts. This reflects the fact that every act must have both interactional and thematic meaning; an act that shifts the thematic situation may theretroduced a distinction between 'texture', the linguistic means by which text achieves its thematic cohesion, and 'structure', the text's internal organization as a sequence of optional and obligatory functional units (cf. Propp 1928, Colby 1973). Halliday's ideational (field of discourse)/interpersonal (tenor of discourse)' distinction is thus parallel to the thematic/interactional contrast used here, while Hasan's subdivision of the textual resources of language into texture and structure is assimilated here to this same contrast: 'textural' cohesion operating in the thematic domain and 'structural' organization describing the interactional regularities of the activity structures, when discourse is to be analyzed not as linguistic potential realized in a text, but as the operation of a system of social action.

Contextualizing operations in discourse

How, in the operation of discourse as a system of action, are the connections of actions to the interactional and thematic contexts in which they have meaning *made*? Where in the discourse processes can we see indications of *which* contexts and systems of cultural knowledge are relevant to the meaning of an act? Discourse must be *self-contextualizing*, within the general cultural system of meaning relations. How does discourse tell us what it is trying to say and to do? Where in a discourse do we feel the relevance of information not explicit in the discourse? How does discourse 'refer by take on a special interactional meaning and illocutionary force. Or the interactive force of a speech act may be formulated explicitly in the content of the utterances (as in 'metastatements',(below).

Similar notions about the dual structure of disourse and situational context have been developed from other perspectives as well. Barnes and Todd (1977) analyze pupils' conversations at small-group tasks in terms of an 'interaction frame' and a 'content frame'. Labov and Fanshel (1977) examine the relation between analysis of 'interaction' and implicit 'general propositions' in the expansion of an utterances' meaning. Erickson (1978) has found it useful to distinguish and relate 'social meaning' and 'referential meaning' in analyzing children's responses to adult communications in a classroom. Mathiot (1980) makes precise categorical distinctions to separate 'activity structures' of event-types as bearers of meaning from 'communicative tool systems'.

Perhaps closest in spirit to the conceptual distinctions used here are those of M.A.K. Halliday (1978) and Ruqaiya Hasan (forthcoming and 1978). Halliday defines three major functional systems of language as a resource for the expression of meaning: the ideational, the interpersonal, and the textual, each responsive to a corresponding aspect of the discourse situation (field of discourse, tenor of discourse, and mode of discourse, respectively). Hasan, developing a theory of the textual system within this framework, has into' its own interactional and thematic contexts? The importance of such questions for sociolinguistics has been emphasized especially by Gumperz (1979), and a great deal has been written about particular contextualizing functions in discourse and text.

The principal contextualizing operations of discourse are already implicit in our conceptual framework, and it will be helpful to clarify them here.

If discourse acts are to have the capacity to alter or maintain the type of the situation in which they occur, the system of discourse must employ resources by which acts are contextualized as situation-specific. This is far from a trivial requirement, much as we may take this capacity for granted, for meaning relations can obtain only among classes of acts (generic acts, act-types), not between unique, non-recurring, non-replicable entities (cf. Saussure 1916 on linguistic signs). Thus acts and words are generic, but in their discourse use they can become as specific to situational context as the generic 'tree' does when 'This tree is dying' is said in an interactional situation where there is one tree. There the use of the generic certainly calls to mind no 'class of all trees' as it does do in 'Trees die' when seen here as a citation form. 'This', a deictic, and the present tense of the time of speaking in the first form perform an indexical operation in the discourse, announcing the relevance of a particular, immediate interactional context and typing the meaning of the utterance to it (cf. Jakobson 1963, Bar-Hillel 1954, Silverstein 1076). In discourse, a generalized indexicality is the pervasive condition of the social meaninfgulness of actions and is not limited by the occurence of such specialized linguistic devices.

A dual view of 'context of situation' calls for recognition that the system of discourse will have the means to tie an utterance or other act to thematic contexts as well as interactional ones. An act may be an index pointing to an interactional situation, but it may also serve as the realization of and a contribution to a developing theme of the discourse. In his sketch of a structural model for narratives, Barthes (1966) formulated such an 'indicial' relation between statements and themes, and Labov and Fanshel (1977) consider thematic 'general propositions' as implicit in expanding the meaning of utterances. We will call these complementary contextualizing operations of discourse the indexical and the indicial.

But we need to be clear that situation-specificity in discourse is by no means entirely accomodative to the pre-existing interactional and thematic contexts: acts are specific to the situations they create by occurring. Discourse acts are creative (cf. the speech act 'performatives' of Austin 1962 and Searle 1969, who unfortunately limit this general aspect of discourse to only some speech acts, perpetuating a folk ideology of language which must itself be analyzed; cf. Derrida 1977, Lemke 1982. Silverstein ms.) in their context of interaction, enacting activity structures and altering or sustaining the definition of the situation-type. And just as acts may call into being new activity types and make whole systems of act-types newly conditionally relevant in the interactional context, so in complementary dual fashion they may *invoke* semantic relations and thematic systems, making them newly relevant for the thematic development of the discourse.

We will add to the two complementary pairs of contextualizing operations so far described, *indexical* and *indicial*, creative, and *invocative*, two more which serve specialized but frequently met with and critical functions: the *metacommunicative* and the *retroactively contextualizing*. Metacommunicative acts 'speak of' the on-going activity structure, giving it a place in the *thematic* context of the discourse and enabling us not only to do, but to tell what we are doing, comment on it, lie about it, and in general develop it as we can any other theme. It is particularly important to realize that 'meta-actions' (Labov and Fanshel 1977) are not limited to verbal statements. Tone of voice, smiles and gestures may (mis-)type and comment on utterances or other acts as readily as propositions (Bateson 1972, Sheflen 1975). Nor may language alone formulate itself and other systems of action explicitly, for the contexts in which such acts can have meaning require the whole system of actional discourse as the framework of metastatements, which cannot establish their meanings within an artificially isolated logical or linguistic subsystem (cf. Habermas 1971). *Meta*'s (as it is easier to call them) punctuate science classroom discourse in a structurally regular way, often serving to mark episode boundaries as well as to orient participants explicitly to the larger scale activities and thematic structures.

Retro's (another useful short-form) also operate within the discourse both structurally and thematically. Among others, Barnes and Todd (1977) and Griffin and Mehan (1979) have noted that where the identification and interpretation of an element of a discourse structure (e.g. the 'triad' above) is contingent on the occurrence of the whole sequence, the appearance or non-appearance of the later members may confirm our expectations or cause us to reinterpret the earlier act's meaning. An act may not be prospectively assignable to a type or an expected structure, or it may have a meaning 'potential' in several possible structures. It is regularly retrospectively that fully contextualized meanings are determinate. Most fascinating, however, in the interactional domain is the use of this characteristic of the actional system of discourse to retroactively alter meanings by re-contextualizing acts into structures divergent from what would normally be expected in the prior context. This is most easily done by retroactive reassignment of the type of an act within the same structural pattern, a common form of class control by teachers. (See Griffin and Mehan's example 29 of an elicitation retyped as a response, and the example below of an answer retyped as a bid to answer.)

Still more complex is the operation of retro's in the thematic domain, by which a teacher may alter or enrich the content of a student answer by retroactively placing it in a wider thematic context relevant to the thematic aims of the lesson. This seems to occur regularly, and the brevity and lack of predication in student answers may reflect their implicit collaboration in this process (Edwards and Furlong, 1978). More generally, the invocation of new thematic systems may require a retrospective multiplication of the meaning of all that has gone before, a basic aim especially of the long-term cumulative and 'spiral' strategies of science classroom discourse.

2.2 Activity Structure and Segmentation

Human activities do not have simple, definite, or 'given' structures. Our analysis of science classroom activity imposes multiple principles of structuration on a corpus of 'data', a record, whose transcription and interpretation may vary with those principles. The practice of applying a principle may engender difficulties or surprises that lead us to apply a modified or some other principles.

The most general notion of structure used here is that of a system of relations of relations...of entities. The kinds of entities and the kinds of relations among them that constitute the structure depend on our purpose and the principles of structuration we apply. A 'unit' is only a unit in relation to a larger whole; some principle is imposed to aggregate (relate) entities to some and not all others to define that whole.

A segmentation is a set of criteria for drawing boundaries in a liner representation of an activity. One may have a minimal segmentation which produces large segments, or a maximal, which produces small ones. Small ones may be aggregated into larger ones, and these into still larger ones, up to the largest, or to the whole available record - this is a 'constituent structure', and at each 'level of its hierarchy of segmentation there is a different principle of segmentation, a different set of criteria. On a given level, all occurring segments may be classified into types in such a way that each segment-type at level N has some definite constituent structure at level (N-1). We will, moreover, need to use multiple hierarchies whose segmentations on different levels may or may not coincide, and whose actual relationships in a lesson may be of great interest.

Science classroom activity in this analysis is taken to have two primary and interdependent structures: a thematic structure and an interactive structure, corresponding to two fundamental princples of segmentation, the first based on 'semantic criteria (change of thematic meaning, topic, what is talked about) and the second or 'pragmatic' criteria (change in the pattern of interaction, act-types, what is being done).

We will use the term sittype for 'interactional situation-type'. To segment the record into units of constant sittype, we make a minimal segmentation on criteria designed to distinguish segments where there is a different pattern of interaction, a different kind of thing going on, a different way of doing things, different norms and expectations about the kinds of things that will happen or be done. This provides a minimal segmentation for the Lesson, though we will also consider the Pre-Lesson and Post-Lesson activity patterns to be sittypes, and thus the Lesson itself is a sittype, but only when contrasted with these two. Normally sittypes constitute parts of a Lesson.

In each sittype there are regularly recurring patterns of act-types. An act-type is specific to its immediately superordinate structure, and thus to a particular sittype (though some forms may have analogous meanings when they occur in a different sittype). Thus the act-type Teacher Question as part of the Triad Dialog structure may have quite different meanings as an act-type in Review vs. non-Review sittypes.

The interactional structuration of social events combines criteria of function and criteria of social interaction patterns, the former identifying the meaning for participants of what is being accomplished through the latter. Participants know 'what's going on' (sittype function) in part through seeing 'what's being done' (act-type pattern).

The thematic structure of lessons is not linear (i.e. has no evident, useful linear representation). One may ask at given time if a theme or thematic system is 'active', i.e. a relevant contextualization scheme for the meaning of what is being said or otherwise done. At any time there will be multiple active themes, which may change there relations to each other. The entry of new themes, the last point when a given thematic system is active, and points where the relations of themes change provide principles of multilinear (maximal) segmentation and criteria for drawing thematic boundaries. The patterns of re-entry of themes and their complex branching, fusion, and interweaving provide principles for submaximal multilinear thematic segmentation.

The thematic and interactional structures of the lesson are not independent. Thus it often happens that thematic and interactive boundaries coincide. Moreover, the boundaries of larger-scale interactional and thematic segments are often marked by participant boundary behaviors such as teacher pauses and proxemic and intonational shofts, and students' postural re-orientation or initiation or termination of side-conversations. (A 'side' is interaction between students that is not part of the common, public, focussed lesson activity, but parallels it, competes with it, or occurs in its interstices, e.g. in Liminal sittypes.) It is possible therefore to make an informal division of the lesson into Episodes, so long as explicit boundary criteria are given, but Episodes are not structural units, they do not belong to a structral *system*. Episodes have *diffuse* boundaries in that application of different segmentation criteria may not exactly coincide. Episodes are specific to particular lessons; they do not recur the way sittypes, act-types, and thematic systems do from lesson to lesson.

Finally, it is important to distinguish between *synoptic* and *dynamic* views of structure. A synoptic analysis considers whole activities in retrospect, and identifies patterns, segments, act-types consistently and often uniquely. It is an analysis of 'what eventually turned out to have happened'. But structure may look very different if one asks 'what is/could be happening *now*' at arbitrary moments during an event. At some points the question may not even be posable, if the meaning system being enacted does not assign a meaning, count what is happening as an event. At other times there may be a 'potential event' or 'part of an event', especially a part of a higher level pattern of act-types or events. At such moments the definition of situation, the pattern *being* enacted, the meanings of the acts are all still incomplete and negotiable, they may become more deeply embedded in larger structures which are eventually completed. The *dynamic* view of structure tries to consider the processes and strategies of making the final structured pattern which the synoptic view describes as a finished product. Dynamic analysis thus subsumes synoptic structure as a limiting case.

2.3 Thematic systems and cohesion analysis

A *thematic system* is nothing more than a fragment of the

Meaning System itself, a certain contextualization of utterances and other acts or events, tying them together by meaning relations which are in one sense distinctive in each thematic system, but more broadly may be taken as special cases of relations such as 'contrast' or 'equivalence', and ultimately of the meta-redundancy relations themselves. Thematic systems are enacted, or developed, through discourse (including the non-verbal actions that are integral to discourse), but they are not limited to particular texts or occasions of discourse (e.g.lessons), but bring these, through their common or related themes, into relations with one another (see Intertextuality, section 3.1). In Chapter 3 we will examine how thematic systems are constituted, or developed, across the 'texts' of particular lessons and episodes.

The notion of a thematic system takes the place in our analysis of that of the 'semantic field' or 'conceptual structure' of a subject. Those notions are de-contextualizing ones, presuming the prior existence of subjects or meaning relations apart from the texts and human discourses through which they are constituted. The meaning relations of any two words or locutions that occur in a discourse or text depend on their context there. That context may be in some sense an 'unmarked' one, i.e. such that the most frequent meaning relations of these words in other contexts is taken to apply here also, but there is always some limit to this 'default option': the meaning relations may be those specific to the register, or the dialect, or what we call the language (e.g. English). But those meaning relations are themselves the product of the uses of the words or locutions on all their occasions of use, separated by the Meaning System of analysts or participants, into those that belong to the same 'language' or dialect, or register, or text; and separated in exactly the same ways as occuring in the same or different contexts. All meaning is context-dependent.

The linguistic devices by which thematic systems are constituted within a particular discourse or text (but dependent on the contribution of intertextual relations) are expected to contribute to the thematic coherence of a text. Textual cohesion, the property by which we distinguish strings of unrelated sentences from coherent discourse, has been investigated by Hasan (Hasan 1981), Halliday and Hasan 1976). Not surprisingly, her analytical methods converge in many respects with those of thematic analysis, and we will sometimes use her terminology. In particular, Hasan defines notions of cohesion chains and chain interaction that are useful to us. A cohesion chain is a set of locutions in the text (usually words or phrases) each of which is joined to one or more of the others by cohesive ties, i.e. by specific meaning relations. Every language has resources for indicating such ties. In English, for example, pronouns and other substitute forms have a tie of 'identity' to the nouns they stand for. That tie may also be established by repetition, by the use of the definite article, etc. Members of a chain may also be tied by whole-part relations (e.g. electron-atom), and class inclusion relations (e.g. hydrogen-element.) Where such relations are implicit in a text as cohesive ties, they constitute the meaning relations of an implicitly invoked thematic system, and the chains may be taken as realizations of themes. But texts do not simply build chains, they establish _explicit_ elations among the members of different chains through local, usually clause-level, syntactic structures. Hasan has shown that our sense of the coherence of text depends critically on its establishing the same _kinds_ of relations between two or more pairs of locutions, each pair with one member in each of the same two chains. In such a case the two _chains_ are said to _interact (chain interaction)_.

From the viewpoint of sociosemiotic analysis, we should note that the system of meaning relations among members of particular chains, and that by which we classify different cross-chain relations as 'of the same kind' are constitutively _dual_ to one another. Neither is _given_ in a text-independent way, except by supposition of some higher-level (e.g. register) context. The meaning relations of whole chains to one another, their interactions, complete the contribution of the text to the constitution of the thematic systems.

3.0 _System Stability and System Change_

We have seen in section 1.2 that sociosemiotic systems are at best dynamically metastable; that is, certain features of the pattern of interactions, viewed in terms of MS categories, may remain relatively invariant due to a complex system of compensating changes. In this framework then we will want to know in more detail how the systems are self-stabilizing and how they change. The same dynamics should account for both, for in the long run change is itself a stabilizing response, insuring the continuity, if not the invariance, of the system. The mechanisms of stabilization must themselves contain destabilizing elements to make this possible. Some of the apparent paradox in this view is characteristic of dynamic open systems, but much is made clearer by looking at the interrelations of Meaning System and Interaction System. Discontinuities in the MS may reflect processes that insure system change, it does analyze ways in which classroom activity structures and strategies of thematic system development may contribute to higher level system invariances (see Chapter 4), thus raising questions of the dynamics of system metastability that bear as well on the mechanisms of system change.

3.1 Ideology, intertextuality, and register

Because of what we have called its 'analytic priority' the MS can serve as a kind of conservative 'censor' of IS interactional processes that might otherwise lead to system change (see section 3.2). The 'unexpected' or even 'unexpectable' event may not even be recognized as an 'event' or as in any way meaningful if it is not MS-contextualized. Or it may be classified as 'meaningless' (e.g. 'a coincidence' 'a mistake' or 'an accident') in its context and 'corrected' or 'adjusted' to a 'normal' form. But the most significant and frequent events by which the MS is itself constituted (or changed) are those of human social interaction, so it is not mainly a question of what 'happens' but of what we do. Human social behavior enacts regular situation types, and is highly limited in its diversity within these. It constitutes and re-constitutes highly stable, if context-dependent, thematic systems of meanings. Why do we not more often do or say the unusual, the unpredictable, the non-redundant? From the IS view one might simply say: because this would represent a breakdown of internal regulatory processes and lead to chaos, to social collapse, to a world where social co-operation needed for system survival would be insufficient. That would be functionally true without telling us how this stability is achieved. There are police, there are mad houses; there is prison, electric shock, and starvation. But social systems do not normally insure stability of human behavior so directly; there are also laws, and norms, and codes of morality and reasonableness: criteria by which we limit the diversity and control the 'appropriateness' of our own and others' behavior. But like the use of force, these explicit canons of control are also reserved for special circumstances. People speak the regular syntax of their social dialect without being able to articulate its 'rules'. Some strings of words, and some combinations of meanings in a context, do not get made, except 'by accident'. If we describe the 'gaps' in a meaning system, we will not find them random; we will find that they function to inhibit bheaviors which might be socially destabilizing by not contextualizing meaning relations of certain sorts. This tunctional subsystem of the MS, a system of absence, we will call its system of disjunctions. At the same time these disjunctions stabilize the IS, there is a sort of 'tension' across these gaps, an area as it were waiting to be filled in or crossed, and thus a dynamic potential for the very system changes they inhibit. The system of disjunctions must cover its own tracks if it is to be effective and persist; there must not appear to be gaps or limits or constraints on meaning. Thus the system of disjunctions must be a global subsystem, the ultimate paranoid fantasy, subtly distorting and distracting possible attention from itself throughout the entire MS. The result is what critical social analysis has long termed an 'ideology', a pattern of beliefs that distorts and 'mystifies' for insiders their perception of social relationships seen quite differently by outsiders, and in just such a way as to perpetuate those social relationships.

We can therefore expect the system of disjunctions to be at work in every thematic system. Thematic systems are contextualized in relation to one another, and one kind of disjunction is the fiction of 'unrelated' thematic systems, or distortions of the relations of such systems. Disjunction is thus expected to set constraints on meanings that can be made both 'internally' within a thematic system and 'externally' by the relations between thematic systems. Looking particularly at the intertextual functions of thematic systems, we see that they serve to help us assemble systems of related discourses, to say that these texts or discourses are 'natural' contexts for one another's interpretation, and those, by implication, are not.

The notion of register in functional linguistics (Halliday 1978) refers to a language variety specific to a particular situational context, defined by the 'field of discourse' (cf. our 'thematic context'), the 'tenor' of interpersonal relations (cf. our 'interactional context') and the 'mode' of use of language in the situation (also 'interactional' for us). But what characterizes a particular register is the way in which its 'meaning potential' is restricted within the 'meaning potential' of the full language. How does a language assemble its registers? i.e. how do texts and occasions of discourse indicate that they belong with some others in the 'same register' and not with still others that belong to different registers? This is precisely the problem of intertextuality, for we may not take situational context as given, apart from how it is constituted thru social interaction, including discourse, so the assemblage of registers thru the intertextual resources of discourse is itself constitutive of the system of relations among contexts (e.g. 'same' or 'different'), and thus of the MS itself. We can in these forms regard register as the paradigmatic system of discourse, just as activity structures provide its syntagmatic system.

When meanings are restricted in a discourse or text, we situate it in a system of registers, hearing it not only in (and as constituting) an interactional context, but in relation to other discourses of a register as employing (and constituting) a thematic system which links some discourses and indirectly disjoins others. What is fundamental in all this is the operation of intertextuality to consitute this contextualization of discourse, and within its restrictions of a wider meaning potential (both within and by separating registers), a global system of disjunctions. Such a view offers us the possibility of moving back and forth between social macrostructure (e.g. system stability, the macrosocial functions of ideology) and microanalysis of situated discourse and social interaction generally. A disjunction of 'macro' and 'micro' methods in the social sciences has largely neutralized their potential for disrupting and subverting the social systems they study, for 'macro' theories, however socially critical, are impotent if they cannot analyze particular instances of social interacton. And 'micro' theories generally fail to recognize the macrosocial functions of what they so carefully describe. The theoretical work of Bernstein (1981) is a welcome exception and converges in a remarkable number of ways in its overall analytical scheme with that presented here. Analysis of meaning systems is a praxis of sociosemiotic change.

3.2 Processes of System Change

Before reviewing the actual procedures and practices of the project reported on here (section 4 below), we can complete this sketch of the general theoretical framework within which this work has been done by briefly considering the analysis of system change, though this is largely outside the scope of this work.

As is, a sociosemiotic system is dynamically metastable and inevitably will produce effects on its environment which will force it to change significantly. Those changes will enact global changes in the MS, but these need not be apparent ones because realignments of the covert system of disjunctions can often provide an illusion of continuity while in fact adjusting meaning constraints to defend the stability of a very different system of social relations. The MS is more conservative than the IS, better able to buffer itself against change. When the MS does change, it is likely to do so radically and discontinuously, even though the IS may--as seen from another MS--shift only superficially.

The MS may shift thru hybridization; that is a sort of 'culture contact' in which two communities, as IS, interact, inducing some hybridization of their meaning systems. Internal diversity within an IS, involving discrepant MSs, is usually stabilized by their disjunction, but the disjunctions cannot be perfectly effective (lest the system lose needed flexibility) and hybrid communities and MSs may form. We have seen that the praxis of sociosemiotic analysis relies on such a hybridization.

The deregulatory process of the IS generate many counterfunctional elements in the MS, contradictory subsystems and contextualizations, loci of tension and potential change. Even the system of disjunctions helps to preserve such change potential at the same time it inhibits these changes. Sociosemiotic praxis mobilizes the counterfunctional systems to escape the constraints of the disjunctions. Merely foregrounding the disjunctions--which requires enacting the 'forbidden' meaning relations and behaviors as well as thematizing their macrosocial relations--provokes 'resistance' in unshifted, nonhybridized communities, but also acts to change them.

Finally, we have noted the possibility of 'slippage' between IS and MS. When acts are performed, MS-typed 'actemes' are realized as actual IS 'acts', just as when we speak, the language requires only that something be said which is recognizable as a 'phoneme', but what is actually said has many 'irrelevant' or 'accidental' features, features that might matter in some other MS; it is a 'phone'. The 'unintended' or 'accidental' features of IS 'acts' have potential IS relations which may enact meaning relations 'compatible' with the MS but normally unrealized because of the disjunctions, or because of the rare occurence of the IS contexts. A 'new possibility' may then be recognized, i.e. the MS will have been changed.

In all these cases the internal dynamics of the socio-semiotic system will almost entirely determine its short-term susceptibility to change. It should be possible, by analyzing those dynamics, to predict the likelihood of particular system changes, and where points of 'leverage' are identified, even to trigger particular, already 'prefigured' changes.

4.0 Analyzing Science Classroom Discourse

In this section we describe the procedures and practices employed in this project, beginning with the process of observation and recording in science classrooms, and the gathering of auxiliary data, then the transcription of recordings and preliminary identification of some of their special features of interest to the project, the selection of lessons and episodes for detailed analysis, and the types of analysis made.

4.1 Data Collection

In the Fall of 1979 and the Spring of 1980, the Principal Investigator, with his research assistant and on 16 occasions the principal project consultant serving as co-observer (two other senior researchers co-observed in three other lessons each) sat in, audiotaped (on 4 occasions videotaped), and made detailed fieldnotes on 59 science lessons by 20 different teachers in two senior high schools, a junior high school, and in graduate and undergraduate classes at a university. All were public institutions, located in a large urban community, with students of a variety of ethnic and racial groups drawn (except for the junior high school) from a wide geographical area within the city. Except for the ethnic and racial diversity of their student populations, these institutions would be similar in most respects to schools in the mainstream of American education, neither 'problem schools' nor elite or 'model' schools. The teachers ranged from those in their first year or two of teaching to those with 20 and more years as science teachers. Among them were only two women and no members of non-European descent groups.

The data on university-level teaching, originally obtained the ways future secondary school teachers are taught science to the ways such teachers themselves teach science, have not been fully analyzed and will only rarely be cited in this report. As it became apparent during the early stages of detailed analysis that only a small fraction of the total corpus could be analyzed adequately in a year's time, deferring analysis of the university level data seemed least disruptive for the principal goals of the project. Much remains to be done on this material.

The principal investigator (P.I.) had worked with teachers and heads of science departments in these schools for a number of years preceding the Project. All teachers participating were volunteers, suggested by the department head and approached by the P.I. Only one teacher declined to participate. In each case teachers were given a very general description of the purposes of the research, but no specific information about procedures to be used by the researchers. This balanced the need for informed consent, most critically to their being taped, against the risk of teachers' becoming self-conscious about particular aspects of their teaching style. At one school the administration vetoed videotaping, but agreed to all other procedures.

Each teacher was observed teaching the same class at least twice; on consecutive days; many classes were followed for three, one for four, and one for five (non-consecutive) lessons. Three teachers (and one university instructor) were observed in two or more different classes. One science teacher was also observed teaching two history classes.

Each teacher was interviewed to obtain information on their academic and teaching history, the course context of the lessons observed, and their comments on how 'typical' each lesson had been. Most teachers were surprised at how little effect the observers presence seemed to have on the class, especially after the first day's curiosity had waned. Most classes were told about the visitors in general, nonspecific terms, and recorders were not concealed, but made as unobtrusive as possible, with no visible mikes. Students who commented generally assumed that it was their teacher whom the visitors were interested in. The observers were sufficiently unnoticeable in the classes that students did not seem inhibited from frequent and occasionally serious violations of classroom 'rules' of conduct. Many of the teachers did at times 'play' to the P.I. in various ways, and these instances are recorded in the fieldnotes. The videocamera, even without a monitor, was scarcely unobtrusive, situated at the front and to one side of the room, with operator behind it, 'panning' across the class and to the teacher. There is no doubt that student behaviors frequently oriented to the camera, and there was no opportunity for habituation. Videotaping was done in a class only after all other work with that class and that teacher had been completed.

The P.I. generally sat on the class's extreme left (teacher's right), near the front of the room, viewing at an angle that by minor turn of head or gaze would take in the whole class. Near him was the Front audiorecorder. At the rear with the Back recorder was the research assistant, Senior co-observers usually sat midway forward on the opposite side from the P.I., also facing obliquely to the class. In most classes seats were arranged in rectangular array, facing a front chalkboard with teacher's desk and long science demonstration table between.

Recorders were usually started during the 'pre-Lesson' period (see Chap. 1) and stopped only during the 'post-Lesson' period. From the time of recorder start to stop, P.I. made continuous fieldnotes, marking in the margin clock-time to the nearest second of events recorded. Start time of Front recorder, together with one or two 'fiducial' events, such as the slamming shut of a door, allow calibration of the tapes against fieldnotes and one another. Other observers noted times for their field observations, though less precisely, and all observers wrote in the fieldnotes snatches of teacher talk to situate non-verbal events in the audio record.

The observers, and especially P.I., followed protocols directing their attention to major sorts of classroom events. First, contextual information needed for the later interpretation of the audiorecord, especially deictic references (e.g. 'Look at this'), writing on the board, use of charts, diagrams, apparatus, etc. This category also included visual cues given by teacher and identification of student participants. Second, information relevent to the assessment of the overall communicative engagement of the class (see Chap. 5), including number of hands raised to bid to answer a Teacher Question, number of students involved in 'side-conversation', percentage of class looking to teacher or engaging in apparently 'on-task' behaviors (e.g. copying notes). P.I.'s fieldnotes were transcribed usually on the same or following day they were made, with the help of the Front Recorder tape; information in original fieldnotes is separated in the transcripts from comments added during transcription.

On the basis of observer experience, conferences between P.I. and the principal consultant, and preliminary analysis of data in Fall 1979 some refinements in the protocols and criteria for observation were made for Spring 1980 (see Appendix). Copies of fieldnotes for one lesson are included in the Appendix. The principal consultant during this first project year of observation and data collection was Professor Shirley Brice Heath (then of the University of Pennsylvania, now at Stanford Graduate School of Education) a trained sociolinguist and classroom ethnographer whose important contributions were fully acknowledged in the Preliminary Report on project year I to NSF, which includes her report (see Appendix.)

4.2 Transcription and Preliminary Analysis

Even before transcription of the audiotapes, the tapes and fieldnotes were analyzed to help define criteria of segmentation, to identify and classify violations of the norms of formal science discourse, and to determine shifts in student communicative engagement with the lesson, to help improve techniques used in later data collection. Segmentation analysis consisted in reviewing a few lesson tapes several times and noting topic shifts, verbal metastatements about the structure of the lesson (e.g. 'OK, now let's go on with...'), and other features that could be taken as marking boundaries within the lesson. This was necessary in part in order to later identify relatively isolable 'episodes' for detailed analysis. Segmentation criteria used in the report are the end product of many revisions of the preliminary segmentation (see sec. 2.2 above and Chap. 1). Norm-violation and communicative engagement analysis provided a monitoring of the potential usefulness of data being collected for eventual purposes of testing an original 'hypothesis' of the project research, namely that in science classrooms teachers do deviate from the discourse norms, or 'style' of so-called 'serious' science writing and lecturing, and that when they do, students are more likely to be 'engaged' with the lesson (see Chap. 4 on norms, Chap. 5 on the relation to engagement). This preliminary analysis was quite helpful in refining the protocols, primarily in reclassifying some types of observed events, further subdividing others, and alerting observers to the value of focussing their attention on certain phenomena and their contexts.

This kind of analysis was eventually done on 12 lessons, with segmentation done on 2 more. Transcription of audiotapes is an arduous and theoretically sensitive process (see for example Ochs 1979). In this project, transcripts are not taken as indexes permitting relevant portions of the original tapes to be reheard, as they were many times, during analysis. I add my warning to many others', which I took seriously, but still underestimated: transcription is a very, very, very slow process and one which constantly requires decisions and judgments. It is not, I believe, a task for secretaries or even trained research assistants. Do your own transcriptions, not merely for 'accuracy', which is a chimera, but to learn, however implicitly, the divergence of spoken and written language, and to get to know your data 'intimately', even unconsciously. Because I relied ultimately on replays of the tapes, no phonological transcription was done, except for a test-case (see below) discussed with an eminent linguist. All hesitations, false starts, repetitions, voiced pauses, and non-lexical vocalizations are included as best one can do in rehearing each phrase a half-dozen times or more. There is no editing to force speech to fit written conventions, tho those conventions must be consciously superseded while transcribing--a running battle against habits that control perception. For orthographic appearances, one convention is adopted that gives rise to pseudo-sentences, tho the sentence is not a unit of spoken language. A detailed study of unvoiced pauses was made, showing a remarkable regularity for each speaker in their durations. Pauses longer than those usual between complete prosodic units with final falling cadence (sentence-like units) are timed in the transcript. Overlapping speech is separated by speaker and onsets of overlap marked; the transcript is to be read in time like a musical stave with different voices running on the same time-line when overlapping speech occurs, or even when one speaker interrupts another briefly.

Lessons and episodes for transcription were chosen by the teacher and student following criteria: good audio quality for purposes of transcription of both teacher and student speech, full fieldnotes by both P.I. and the principal consultant, availability of a 'comparison' lesson in the same class (usually for the preceding or following day), significant variability of the indices of engagement, and occurence of a number of discourse norm-violations. The relative priority of criteria were in the order listed. Three complete lessons (one at university level) were transcribed and portions ranging from 10 to 26 minutes of the approximately 40 minute length of 5 others (plus episodes from university classes). The corpus is described in detail in the Appendix.

4.3 Discourse Analysis

The results of the preliminary analysis and the experience of transcription clearly showed that the meanings made in these lessons were highly context-dependent and that an earlier plan of isolating episodes of high and low commjnicative engagment for comparison of their discourse features would have to be abandoned. All comparative analysis would have to wait on gaining an understanding of the structure and dynamics of a single lesson. The lesson chosen for a detailed analysis was the fully transcribed senior high school lesson (code DRS).

Available analytical schemes, (See section 2.1) proved useful starting points, but all concentrated on the interactional sturcture of the lesson and paid scant attention to thematic development. It was clear that the lesson dynamics in our corpus depended as much on the 'science' system of meanings as on the 'classroom' system. These were not just lessons, 'about' something. The schemes also tended to emphasize decontextualized act-types with fixed meanings, rather than the contextualizing relations central to our theoretical framework. A Teacher Question might well 'initiate' an exchange, but what happens subsequently depends on whether the question is 'easy' or 'difficult', whether the activity in progress is a review or not, whether it is recognized that the teacher is calling on a student who was 'not paying attention', whether the question introduces a new theme or synthesizes existing themes, and many, many other contextual features. Thematic analysis, and the related cohesive analysis (see sec. 2.3 above and Chap. 3) were done in parallel with interactional structure analysis, and lesson DRS was analyzed 'word by word' and 'act by act'.

The fine structure of the dynamics of meaning in discourse is richly revealing. The initial analysis of the first episode of lesson DRS (hereafter DRSI) produced so many insights, and yielded new patterns with each now question for 'interrogating' the data, that I recognized the ultimate value of an exhaustive analysis of this short segment (less than 2 pages in transcript, about 4 minutes of tape, with less than 3 minutes of verbal lesson discourse). To date I have approximately 90 detailed pages of notes on this episode, which might run to 200 pages of typescript if fully written out and explained. The analysis is far from complete, tho it is a good beginning.

How can there be so much to say about a few minutes in a science classroom, most of it concerning the 'public focus' activities of teacher and students (neglecting all the other activity in the room)? Analysis began by posing an interactional structure issue: how do lessons get started? This led to a contrast of pre-Lesson and Lesson 'situation-types', the identification of what kinds of things teacher and students did to enact these, and the shift from one to the other (see Chap. 1). Then of each utterance in the lesson discourse, it was asked: What does saying this do? and how? Utterances are plurifunctional, and analysis begins by asking what they might do and then looking for evidence they have done. Every word-choice, syntax-choice, intonational & prosodic cue was interrogated as to its possible interactional functions in the IS, in the regulation of behavior, and in the MS, the enactment of a socially recognized act-type in a situation-type. This analysis soon made clear that interactional meaning, the 'status' of acts, depends on the completed structures in which they will have occurred; thus later acts retroactively recontextualize the meanings and effective functions of earlier ones. Thematic meaning cannot be neglected in this analysis; what an utterance does very often depends on its thematic meaning (Chap. 2), and one of the things utterances do is to invoke and develop thematic systems of meaning - i.e., to 'teach science'.

The entire episode was then reanalyzed for thematic development: What thematic systems are invoked, and how? How are the meaning relations of various themes expressed in the discourse? How are new topics introduced? linked to other topics? The results led ultimately to the analysis presented in Chap. 3. At the same time, several other auxiliary modes of analysis were employed that supported the interactional and thematic analyses: Cohesion analysis, asking quite generally: What about this word, act, theme, act-sequence, etc. in any way links back (or forward) to others in the episode? This was done with analysis of the linguistic signs of relevant interactional thematic contexts (indexicality analysis, and limited intertextuality analysis). The distribution of syntactic structures in relation to discourse function and thematic development was analyzed. This revealed the inadequacy of much grammatical theory for the analysis of (a) spoken language and (b) mathematical-symbolic language. The episode was also analyzed according to a scheme proposed in one form by Volosinov (1930), and then to me by Courthard (pers. comm.): How can each utterance be seen to function as part of an implicit dialog, as if anticipating a response and as if itself a response to an unvoiced question, request, etc. This clarified a few points (the monologue basis of 'triad dialog', see Chap. 1; the functioning of retroactive discourse moves) but was not as helpful as the principal modes of analysis already mentioned.

These analyses were conducted while in contact with discourse linguists in Britain and in Australia. On a first visit to Britain there were helpful conversations with John Sinclair and Malcolm Coulthard in Birmingham (on discourse structure and dynamics): L.M. O'Toole at Essex (thematic analysis); Anthony Edwards in Newcastle (classroom discourse); and in London with Harold Rosen (classroom language), Henry Widdowson (discourse linguistics), and Roy MacLeod and Ina Wagner of the University of Vienna (social studies of science, science ideology). During a vist to Australia, conversations with Michael Halliday and Ruqaiya Hasan were extremely helpful in re-examining the role of syntax using functional grammar, in the cohesion chain and interaction analysis, theme/rheme analysis, and analysis of information focus and intonation. At this time I also began to see the importance of intertextuality and did a preliminary analysis of a later episode from DRS. On the second visit to Britain, conversations were renewed with those already mentioned and in addition new dialogues were begun with Basic Bernstein (sociology and discourse) in London, David Brazil in Birmingham (discourse and intonation), and Douglas Barnes of Leeds (classroom language). I would also like to acknowledge critically important conversations on the relations of ideology and register with Paul Thibault, a student of Halliday's then at the University of East Anglia, and with Lawrence Goldman of Trinity College, Cambridge on social ideology and the study of social change.

From all these modes of analysis a synthesis developed, which was in turn simplified for the purposes of answering the major questions about science classroom discourse treated in Chapters 1 through 5. This synthetic method was developed in the analysis of the remainder of lesson DRS (40 pages of notes on the remaining 35 minutes of tape, 18 pages of transcript, following the initial episode DRSI). This method was then used to analyze the other transcribed portions of lessons (in all an additional 87 minutes of lesson time in 5 lessons by 5 other teachers). Analysis was now on a 'utterance by utterance' scale, with focus shifting between interactional and thematic development, or specialized discourse features, as the text offered opportunities to refine earlier formulations.

4.4 Analysis of norms, norm-violations, and communicative engagement

As described in more detail in Chapters 4 and 5, the final stage of analysis was the identification of violations of conventions of 'serious' science discourse, an analysis of the social functions of those conventions (Chapter 4), an analysis of the patterns of rising and falling student communicative engagement with the lesson--defined largely from fieldnote records of behavior not recoverable from the audiotapes, and confirmed by analysis of the videotape records--and an examination of the hypothesis of greater engagement with norm-violating than with normal discourse. The hypothesis was strongly supported (Chapter 5).

Left undone was much that had originally been planned.

The junior high school lesson, fully transcribed, formed part of a data 'reserve' (including also the comparison lessons for each class) which was to have been analyzed to extend the generality of findings, and permit identification of idiosyncrasies of individual teacher's styles. The whole of the university-level corpus remains to be analyzed in detail, its original purpose to provide a sample of normative science discourse, and a basis for comparison with the secondary school data. The corpus exists and is well documented. There is much yet to be learned from it. What has been learned so far is reported in the following chapters.

END OF PROLEGOMENA

CHAPTER 1. WHAT'S GOING ON: SCIENCE CLASSROOM SITUATION-TYPES

1.0 The Notion of a Situation-type

The meaning of verbal as well as non-speech actions depends on the context of situation in which they occur. The occurrence of a recognizable pattern of act-types sustains a definition of what the situation type is, of what kind of activity is going on. Most often the immediate, short-term pattern is itself part of a recognizable longer time-scale pattern.

If we ask a regular participant, or an observer familiar with these patterns, "What's going on now?" we might hear: "we're going over the homework," or "they're doing science," or "she just got the answer." 'Having a science lesson' as an activity may include a segment of 'going over homework' and one event within that activity might be 'getting the answer'. If "she just got the answer" meant that another student had just said something our respondent took to be the correct answer to the teacher's last question, we will not call this event an 'activity' or 'situation-type' because it is not a kind of event that in science classrooms may ordinarily be of extended duration. It is more an answer to the question "What just happened?" in the sense of implying a single definite completed action, than to "What's going on?" or "What's been going on?" in the sense of a continuable activity. The distinction is like that of grammatical aspect in the verbs of many languages (e.g. perfective/imperfective, punctual/durative). The single act of 'getting the answer' is also an event which in itself requires only one participant role (though it is part of an activity with multiple roles, e.g. part of 'question-and'answer'). It is not in itself a pattern of group activity. It is rather at the base of a hierarchy of events of increasing complexity, each level integrating and providing the interactional context for the meanings of those at the level below. The basic theoretical ideas behind such a hierarchical description have been outlined in the Prolegomena.

We are taking up the problem of the characteristic situation-types of the classroom at the beginning of our discussion of discourse strategies precisely because which strategies occur when and with what meanings and functions depends on what situation-type is recognized as prevailing by the participants. What they do ratifies, challenges, negotiates, or alters the definition of the situation-type and it takes its meaning within that situation-type.

What changes the situation-type? i.e. what kind of changes in what people are doing may alter the prevailing sittype? How do sittypes get initiated? terminated? revived? modified?

What are the characteristic, frequent, normal, expected, obligatory, and optional sittypes of the science classroom?

(The transition from the long form 'situation-type' to the more convenient short-form 'sittype' is probably an obvious one to most readers; the establishment of such equivalences through discourse is discussed in Chapter 3. In this text the equivalence is unrestricted; the two forms are interchangeable in all contexts for all purposes -- except of course in the first sentence of this paragraph.)

Some limits to our discussion of science classroom sittypes need to be set. We will not consider activities that occur in science classrooms but have no structural relations to the formal 'science lessons' that are the focus of this study. On one occasion, for example, a science teacher held a 'homeroom' or 'official attendance class' in the science classroom. Participants entered, talked, read and wrote, exchanged paper, and left. No science topic was discussed. The teacher and some of the participants stayed on for a 'science class' in the same room a few minutes later. No participant would maintain that the earlier activity was in any way, even as prelude or lead-in or preparation, a 'part of' the science class. We will not count it as a science classroom activity for purposes of this study. Nor woud we - or they - count a 'science club meeting' in that room, even with effectively the same set of participants as in any way part of a science class. We will consider activities of the participants (in the room) before the 'lesson proper' is recognized to have started, and those just after it ends, as well as interruptions and 'non-science' activities during the 'lesson'. These are needed for at least the syntagmatic (structural) analysis of the patterns of action and meaning enacted by certain people in a setting over a continuous period of time. We will not make a paradigmatic (contrastive, 'systemic') analysis, comparing activities of a science class to other school activities (e.g. 'official class' 'English class' 'science club' 'hanging out' 'assembly') or to non-school activities. Because of this our definition of 'science classroom activities' or 'science lessons' is strictly a constitutive one (what goes on in them that makes them what are called 'science lessons') and not a contrastive one (how they differ from other members of a larger, more general category of events). Both sorts of definitions are useful, but this project's data provides a basis for making only one of the first sort.

Finally, for the remainder of this chapter we will be restricting ourselves to differences in interactive processes, neglecting differences in the thematic context of situation. Thus the sittypes we will consider differ in the structuring of what kinds of things participants are doing (including doing by saying, e.g. asking, challenging) and not merely in topic or relevant thematic system.

2.0 Some Science Classroom Situation-types

The dominant sittype of science classroom activity is the (science) Lesson. It (almost) always occurs, and usually prevails for the largest number of minutes of the period of each observation (from the time of prospective participants entry to the room until they have left). It is universally recognized by participants and its dominance is reflected by the frequently synonymous use of the terms 'lesson' and 'period'. It has a recognizable internal structure, but it is most clearly seen by contrast with the Pre-lesson and Post-lesson sittypes that also occur in what we may call the 'extended period' (period of observation), to contrast it with the somewhat shorter 'official period' from bell to bell. We will give, below, a detailed discussion of the process of getting the lesson started, which effects the transition from Pre-lesson to Lesson as the prevailing and recognized sittype, with concommitant shifts in speaking rights, norms of appropriate action and topic, etc. that distinguish these sittypes.

All other sittypes are taken to be (possibly optional) sub-activities of the Lesson. An important special sittype is the Interruption. Without warning, in the midst of another sittype, the fire alarm rings, the principal's voice intrudes over the public address system, a stranger enters the room, etc. Usually there is a shift in participants' behavior; a new pattern begins to be enacted. After the Interruption, very often the previous sittype is reinstated (rather than a new sittype); not only the Lesson but a particular sittype is renewed. Because Interruptions may have consequences for the interpretation of some of what happens in the remainder of the Lesson, they are considered here to be parts (perhaps anomalous ones) of the Lesson, even though participants might not so consider them.

Different from an Interruption is a Liminal period (borrowing this term from Victor Turner's symbolic anthropology of social activity), when one lesson episode seems to have ended, but another one has not yet clearly begun. This is a sittype in itself. It is a very common time for students to take some initiative (e.g. ask a question of, or make a request of the teacher), and it is a time of postural shifts, quiet side-conversations, etc.

There is a rare sittype, Disorientation, when participants are confused as to what is going on, what the prevailing sittype is. Many participants do not recognize the pattern which others' (especially the teacher's) actions fit, and they try to clarify the status of the situation.

Finally, among the special sittypes, is Negotiation or conflict in control of the definition of the sittype. In these circumstances different participants may be enacting patterns they recognize to be different from those being enacted by other participants. We should probably also mention here a distinction between Confrontation (between teacher and one student, teacher and the class as a whole, one student and another) as a sittype, which is infrequent and has no regular syntagmatic relations to other sittypes within the Lesson, often being 'bracketed out' from the rest of the Lesson in much the same way that Interruptions are, and single events of Teacher Admonition of one or a few students, which are not taken to constitute a sittype at all.

Having surveyed these special cases, it is useful to have an overview of the sittypes of the lesson proper, before we go on in this Chapter to give detailed descriptions and examples of how the various sittypes are interactively constituted.

At some point during a lesson the teacher may say: 'and then we'll get to the lesson for today' or 'now this is today's AIM' indicating thereby that what is beginning or hasn't yet begun is the most important, central, or principal part of what we are calling the Lesson. This 'lesson head' or 'lesson nucleus' (cf. terminology of Sinclair and Coulthard or of Kenneth

Pike), or as we will call it, the Main Lesson, is not a sittype, though it is a recognized structural division, usually the largest, of the whole lesson. It usually coincides with, or creates, an episode boundary (perhaps only a topic shift or pause) when it begins, and it continues over several, often all the subsequent episodes and their associated sittypes.

Certain sittypes normally precede the Main Lesson. These include Class Business (taking the roll, announcing class or school events, collecting and distributing paper, etc.), the Do Now (an individual seatwork task often written on the board at the start of the period), Going Over Work (e.g. reviewing homework, discussing outcomes of the Do Now task, discussing answers to a previous test), a Lecture (in the special sense of the teacher's lecturing the class on its behavior, academic performance, etc.) and Review (of previous class work). We will later make a more careful classification according to which Review is regarded as a functional class of sittypes, which may differ in the pattern of organization of social interaction by which the function is realized, in the same way that one can have Seatwork as an interaction-structure class of sittypes that may realize various functions. A true sittype then, such as Going Over Work, is specified both with regard to function and to pattern of organization of social interaction, but the looser terminology is better adapted to describing sittypes as participants see them with now function, now interaction structure foregrounded.

The initiation of a line of thematic development in a lesson is often accomplished in and through a teacher Narrative sittype or a science Demonstration sittype, recognized by many teachers as two ways of 'motivating' student interest in the topic of the lesson. The first is usually a short joke or story with some connection to the lesson topic; the second is a visual display and discussion of some materials and processes (or their representations) relevant to the topic.

The most common sittype for continuation of thematic development (though it occurs in other functional roles in the lesson as well) is that of Triad Dialog, a sittype (class) named for its characteristic minimum ordered triple of participant actions: typically, a Teacher Question, a Student Answer, a Teacher Evaluation of that answer. The full system of options is quite complex and is discussed below, where we find general agreement with the analyses of Bellack, Sinclair and Coulthard, Mehan, Griffin, and others, but bring out some additional features.

Alternatives to the usual Triad Dialog situation may occur when students take thematic control or interactive initiative (Student Initiated Dialog), when the dialog is restricted to a Duolog between teacher and one student, and when students assume a less constrained and more nearly equal role as in Teacher-Student Debate.

In addition to these dialog modes, we encounter teacher Explanations (extended monolog explanations), Summaries, and such sittypes as Seatwork (individual work at seats by students with teacher often circulating around) and Copying Notes (teacher writes on board, students copy into notebooks).

We will now move on from this informal sampling of some of the principal sittypes of science classroom activity to specific characterizations of each type and to consideration of the multiple structurings we may usefully place on a lesson. We will consider first the beginnings and endings of lessons, then sittypes which normally precede (or rarely follow) and those which normally occur within the Main Lesson.

3.0 Pre-Lesson, Lesson, and Post-Lesson Activities

3.1 Getting the lesson started

A set of approximately simultaneous, or at least rapidly successive shifts in the pattern of social behavior of participants may be identified as marking a boundary between a Pre-Lesson situation-type and the first sittype during which we recognize that the Lesson has begun. Teachers recognize this boundary, saying that the class 'settles down', 'gets quiet', 'gets to work', or 'starts to pay attention'. A detailed analytic description of a fairly typical set of contrasts between Pre-Lesson and Lesson situations in one observed period is given below. In that analysis we see the usual pattern of a teacher initiative which functions, inter alia, to realize an act-type, Bid Start, which may take the form of a complex action sequence: the Teacher closes the classroom door, comes to the front center of the room, and begins to speak in a public voice. Its meaning as a bid to start the lesson, i.e. for students to shift their pattern of interactive behavior, depends in part on conventional features of the interactive situational context: the bell has rung, it is the normal starting time for this 'official period' as a part of the school day devoted to Lesson activities, etc. It depends also on its contrastive meanings: the closed vs. open door signals that students are not expected to enter after this time when the Lesson begins, the teacher's being up front facing the class vs. being behind the desk or demonstration table facing the board or talking to a particular student, and speaking in public voice addressed to the class vs. talking in a non-public voice addressed to a single individual - in this setting all these mark typical changes from teacher Pre-Lesson to Post-Lesson behavior.

Getting lessons started is a joint accomplishment of teacher and students. Students' behavior must ratify the Bid Start to produce a recognized Start for the Lesson, and students may not, or not immediately do so. They may fail to recognize a Bid Start, may ignore it and begin a Negotiation or even a Confrontation situation. Teachers may also withdraw the bid or simply fail to continue with their side of the Lesson pattern of interaction, perhaps as a concession in the implicit negotiation, or because they realize they are not ready to begin yet. Retrospectively, we would classify some Bid Starts as failed or false starts, especially when the teacher later makes a successful second (or fifth) Bid Start. False starts consist in the same sorts of acts as successful starts, though perhaps they conflate fewer redundant cues.

The most common act-type of Negotiation is teacher's Pause for Attention, usually accompanied by some students' "sh-sh!" to others. Teacher may also name a student, an act which in this context is interpreted as a request for behavior appropriate to the sittype teacher is trying to bring about, and perhaps as a warning or threat to the student. It is also a message to the class as a whole, since this kind of Admonition (see Chapter 2) is part of the regular behavior control routine during a Lesson.

Consider the following repertory of verbal and nonverbal Bid Start actions by teachers:

Common Nonverbal Bid Start Acts by Teacher

--erase boardwork of previous class
--close door
--go from behind desk or table to front
--stop writing, gaze at class
--sit on front of desk or table facing class
--write Do Now or Notes-to-be-copied on board
--stop talking to students individually; speak in public voice

Actual Bid Start Utterances by Teachers

Direct: 'Come on people, let's go. We're already late.' (EG-7-1)
'All right, c'mon..focus!' (KF)
'All right, youth..let's get started.' (RN, actual start)

Activity allusions: 'Before we get started..before I erase the board' (DRS)
'OK..now open up...' (BB)
'Alright, would you please find your seats.' (NOR)
'Alright, please get seated quickly' (RN)
'OK. As we can all see, we have three Do Now questions on the board...' (WE)

Continuity/resumption: 'Yesterday we talked about minor changes in the earth's crust.' (SC)
'Now on Friday we were talking about...' (JR-6-1)
'...continuation of what we were doing yesterday' (BB, part 2 of Bid Start)
'For the benefit of those people who may have been absent yesterday, we started a two-part.. situation concerning itself with entropy.' (SST)

Pre-Main Lesson starts: 'Before we get started...' (DRS)
'Two brief reminders and then we're ready to start.' (LG)
'I'd like to ask you a couple questions before we start' (BB, part 3 of Bid Start)

These Bid Starts were all successful. Some were complex utterances, one teacher (RN) started the lesson twice. One (JR) is represented by the starts of two different lessons.

KF, EG, and RN (actual start) begin by a direct call for the start of the Lesson. The unmarked direct start we can suppose is: '/Bdry wd/, let's get started.' where /Bdry wd/ stands for one of the frequent boundary marker words of classroom discourse (cf. Sinclair and Coulthard, 1975): 'Now' 'OK' 'Alright' etc. The command 'Focus!' by KF is idiosyncratic, but articulates the analyst's notion that a single central focus of attentiveness or concerted activity is a prime marker of Lesson vs. Pre-Lesson or Post-Lesson sittypes. 'Let's go.' is idiomatic, the situational context supplying the metaphoric sense of 'go.' EG's 'we're already late' incorporates the inclusive first person plural feature found in eight or nine of our examples, appealing to the solidarity of teacher-student co-operation which characterizes, ideally at least, Lesson sittypes. It also enacts an element of 'pacing' (cf. Bernstein, 1981), a mode of teacher control, and belongs to the same meaning complex as the closing of the door (Being Late).

DRS (second clause), BB (part 1), NOR, and RN (first bid) Bid Start indirectly by alluding to characteristic activities of the start of a lesson: teacher erasing the board, students opening their notebooks (BB), students sitting down in their seats. WE is cited as representative of several Bid Starts that in themselves identify the initial activity of the Lesson: in WE, a Do Now; in EL, a teacher Narrative ('Now let me tell you a little story, OK?'). The regularity of this sort of Bid Start enables students to interpret initial utterances by teacher such as HL's 'I take it from all this talking everyone finished doing all the work.' in the context of an expected Lesson start with a Do Now up on the board. Students take HL to mean: quiet down and work on the Do Now, the Lesson is beginning. His Bid Start is admonitory, for if the Lesson has begun, then talking is inappropriate; moreover, there is a 'pacing' component to the meaning: only a certain time is allowed to 'finish doing all the work' - i.e., the Do Now seatwork task - and students are responsible for 'getting down to work' so they can quickly finish.

SC, JR-6-1, BB (part 2), and SST all Bid Start by invoking a resumption of work previously begun. Teachers see this mode of Bid Start as emphasizing continuity from lesson to lesson. It has typical features of a past-tense verb and 'yesterday' or other past time adverbial, often indexical to prior class work. We can suppose that forms like 'Alright, yesterday we talked about...' are as regular and unmarked Bid Starts as 'OK. Let's get started.' The activity allusions are usually 'marked' in the sense of carrying special interactive meaning beyond simply that teacher wants to get the Lesson started.

DRS (clause 1), LG, and BB (part 3) all use a common, if perhaps unexpected, 'pre-start' locution as a Bid Start: 'Before we get started' '...and then we're ready to start.' '...before we start.' The generic formula is effectively: 'Let's do /X/ before we start the lesson.' These are Bid Starts nonetheless, and as we will see in the detailed analysis in the next section of DRS's start. The apparent paradox points up the double use of 'start' and 'lesson' for the start of the Main Lesson (structurally the obligatory lesson-head, or lesson-nucleus), the episodes of principal thematic development of the Lesson as a whole, dealing with the science content of the Lesson, as well as for the whole Lesson. Between the start of the Lesson and the start of the Main Lesson occur a number of characteristic pre-Head sittypes. We will take these up after looking at how lessons end and at the Post-Lesson situation. Starting the Main Lesson will be discussed in section 5 below.

3.2 The Start of Lesson DRS

A classroom, in this case a traditional rectangular one with teacher's desk and long science demonstration table just in front of the blackboard, facing rows of regularly spaced student desks, is a setting in which many activity types are enacted other than 'lessons'. An observer or participant may at one moment, if occasion arises, say 'the lesson hasn't started yet' and at a later time note that a lesson is surely going on in that classroom. Certain culturally salient features of the interactional situation will have changed; both teacher's and students' behavior will be differently patterned. Their joint actions have 'gotten the lesson started'.

The fieldnotes and tapes for roughly the first two minutes of the record (see transcript lines 1 - 10) present a complex interactional situation. Over 20 students are in the room, and several more enter during this time. The room is noisy, students are both standing and sitting; the teacher is at the blackboard with one student, and many student-student conversations are taking place. One student, call him the Joker, is talking loudly for effect in a 'hypertense' artificial voice for the enjoyment of his friends. A student enters and, standing in the front of the room, calls attention to himself with a loud, contoured 'Hey!', echoed by his friends, seated towards the back of the room. Some students are tossing something around among themselves. Another student enters and engages a friend in a mock fight, screeching when her friend counter-attacks. The general noise level rises and falls, with a few brief but noticeable lulls. The teacher continues his conversation with one student at the board, looking at a complex diagram in colored chalk. No one is acting as if this situation is abnormal or sanctionable.

Then over a period of about 15 seconds the interactional situation shifts radically. The teacher addresses the class (lines 11 and 13) rather than one student (who has gone to his seat), implicitly acting to create a 'class' from what were a dozen or more non-interacting, independent individuals and groups. Gradually, more of them reorient their gaze and postures (all are seated now) to the teacher and end their separate conversations. There is a decrease in the diversity of different activities in the room (no 'fighting', 'displaying', 'throwing things around'). A new set of rules of appropriateness is coming into play, as signaled to and enforced by the students on one another (lines 12 and 15). Teacher and students are redefining the interactional situation-type.

The first identifiable act in the creation of 'lessonhood' is teacher's turning to the 'class' and saying 'Before we get started,...' (line 11). His earlier utterance, 'Yeah.. aw right...' (line 4) is lexically of a form teachers often use to signal the start of a lesson, and was loud enough to be clearly audible in the room, but there was no class response at that time. As a social act this phrase had been said, evidenced by kinesic and proxemic features, to one student. It was appropriate in a situation where many, loud 'private' conversations could co-occur, and its occurence sustained that situation-type as 'non-lesson'. The new 'public' utterance is followed by a pause, a common interactional cue that the speaker is waiting to be sure of a listener's attentiveness. Moreover, as a subordinate clause in form, it is heard as incomplete, as part A of an A - B structure. The form should act to attract attention to an anticipated part B, and to the speaker. Its use of 'we' is indexical, defining the situational context as one in which there is a solidarity of speaker and listener (there being no exclusive group for which the teacher would obviously be speaking). The utterance also operates as a meta, formulating the situation of 'getting started' even as it acts to achieve what it speaks of. Meta's frequently mark activity structure boundaries. As both a meta and a performative for starting the lesson, the utterance is paradoxical: 'Before...' implying that starting is yet not really 'getting started'. This indicates that the performative is operating in relation to at least two contexts: it begins the lesson as such, and it announces the start of a structural unit which it defines as being preliminary to the main business of the lesson. In doing so it weakens its primary force slightly.

'... before I erase the board ...' (line 11) immediately follows. In many respects it is parallel to the first clause, a repetition (in its syntactic form, intonation, length, incompleteness with a following pause). As a re-petition it both augments and admits the ineffectiveness of its predecessor. "We' has become 'I', a shift from solidarity toward 'I, the teacher' with its implication of power. And 'erasing the board' alludes to a classroom ritual of erasing what is left on the board from the previous period's work as preliminary to starting the lesson. Thus, performatively, this second clause is just as much a call to order as was the first, if subtler in its thematic cues.

As the teacher pauses this time, several students make a loud 'Sh!'

sound. We heard many vocal forms in the first two minutes, but 'Sh!' occurs in, or acts to create interactional situations where speaking rights are constrained and would have been out of place then. It functions as a signal to other students that the lesson is starting, thus retroactively ratifying the force of the teacher's utterance as a 'bid to start', and as an act of support for that bid by being itself a form appropriate to 'lesson in progress', but it also has meaning as a bid by some students for a dominant, commanding role in relation to other students (who often react negatively to such a bid as a challenge). In this last context, it runs counter to the establishment of 'lessonhood' by prolonging an essential feature of the pre-lesson situation: that students interact directly with one another on the basis of relationships other than that of 'class members' and external to the interactional context of the lesson (recall the fighting and displaying as well as the private conversations).

'Uh... Look how fancy I got...' Here the teacher makes a direct demand of his own, that students 'look', sc. at the colored chalk diagram on the blackboard. He does not, as teachers often do, disapprove students issuing commands like 'Sh' to other students. He thereby tacitly welcomes their action, retroactively defining it as solidary with rather than competitive with his authority. The teacher's imperative, however, is far from a stern formal command. The hesitant 'Uh', the colloquial 'fancy', his voice trailing off casually at the end of the utterance, his smile (almost a grin), make the use of 'I' here a personal (rather than positional), almost self-deprecating one. (We can legitimately suspect a long-term thematic context, that the teacher is not known for his artistic skill at the board.) He is proud of his handiwork, he drew this during the previous period as we later learn, and invites a sharing, thus acting to initiate a new feature of the interactional context: the personal interest of the board diagram. He has also accomplished a shift from his earlier 'private' indexing of the board diagram (line 4) to a 'public' one here, contributing to the shift from the pre-lesson situation to 'lesson'.

Next (lines 14 - 15) the Joker, self-absorbed or carried away, loudly talks in his funny voice to a friend, provoking student 'sh!'s, this time clearly aimed at controlling an individual and not just at a general clearing of the communication channel. Behavior which 15 seconds ago was acceptable is now inappropriate, and by disapproving it, students further establish the new situation-type.

'This is a. representation. of the. one. S ... orbital.' (line 16) With the situational shifts the teacher accomplishes here, the lesson is unquestionably underway. His indexical (deictic) statement creates a technical thematic context for the board diagram that contrasts with the personal one above. The use, and foregrounding by pauses, of a non-technical formal term, 'representation', contrasts with the colloquial 'fancy'. The technical terms 'orbital' and '1S' invoke thematic systems newly relevant to the meanings being shared here (e.g. 1S contrasts with 2S, 2P, *1P, etc.) He is not only 'teaching' now, he is teaching science.

3.3 The End of the Lesson and After

By comparison with the Pre-Lesson situation type, the Post-Lesson tends to be much briefer, perhaps less than one minute, since typically the science Lessons observed continued until, or past, the bell signalling the end of the official period. There are rare cases, when teachers have completed a major section of thematic material and they and students are unwilling to begin new content with only a few minutes remaining, or in other special circumstances, that students are left to themselves for the final minutes.

We will not class this as the true Post-Lesson situation, however, since students are not yet released from the authority of the teacher, most students remain seated, and conversations among students are less loud and more physically subdued than they are after teacher has genuinely ended the Lesson. When the bell, or another action by the teacher does end this quasi-liminal situation-type (Quiet Free Time), the normal features of Post-Lesson activity occur. Quiet Free Time is thus best thought of as a post-Head (i.e. following the end of the Main Lesson) sittype, but still part of the Lesson.

How are Lessons ended? By somewhat the reverse of the 'getting started' process. But where it is usually the teacher who Bids Start, and students who must ratify the bid, it is students who usually Bid End, even if no bell has rung, and even if some short-term activity structure is still in process of being enacted and incomplete. Students will look away from the teacher, at one another, close their books or notebooks (all normal bids so far), put on their jackets (a strong bid), or even stand up and move away from their seats or leave the room (asserts End as much as Bids for it, leads to Confrontation unless teacher ratifies End). These actions are themselves distinguishable as part of the End pattern - as opposed to students merely getting up from their seats, say, in the middle of the Lesson - by the hesitations and glances to teacher and other students at each stage of escalation to stronger bids. It is interesting that verbal bids to end the lessons are rare, mainly occuring when teacher has completed a segment and appears to be beginning a new one. Then students may say 'The bell's about to ring' or 'My hand's getting tired writing.' Teachers do not normally ratify a Bid End before the bell, but signal that the lesson is to continue. They may say 'The bell hasn't rung yet' or 'Hold on, we've still got five minutes left' or 'You'd better copy this' (e.g. responding to notebooks being closed), and they will continue their current action-pattern: writing on the board, giving a summary, etc. Students may withdraw their bid (by re-opening notebooks, attending to teacher, ending side-conversation , etc.), sustain it, or escalate it. When the bell does ring, the balance of power in this Negotiation shifts from teacher to students. If there has been no previous Bid End, the bell itself counts as one and will be rapidly escalated by students. Teachers must scramble to postpone End; they may say 'Wait-wait-wait!' or 'Hold on, let's just finish this.' or 'Freeze!' usually loudly and very quickly. If students hesitate, teacher will continue and try to complete a segment. This is of course an excellent opportunity to observe indirectly what counts as a completed segment for teachers. If the students do not respond, teacher will usually concede gracefully by effectively withdrawing the Bid to postpone End and ratifying End. End locutions and nonverbal signals are relatively stereotyped for a particular teacher. They include: /Boundary marker words/, e.g. 'O.K.', references to the future ('see you tomorrow' 'we'll finish this on Monday') and dismissives ('Bye!' 'Go!').

Once the lesson is over, students usually leave the room quickly, talking to each other. A few will come up to the front of the room to talk to the teacher or to examine materials at the front or finish copying something from the board. Noise levels are comparable to those of the Pre-Lesson period, but speech and movements are quicker, as if time were more pressing. There is effectively a reversal of the Start behavior shifts described above, so that Post-Lesson and Pre-Lesson seem distinguishable mainly by the criteria of haste vs. leisure, and of course, standing and leaving vs. entering and sitting down.

3.4 End Phenomena: Some examples

If we consider the Endings of some of the same Lessons whose Starts we have already described, we can illustrate several End patterns.

In JR, EG, and SC the bell itself effectively ends the Lesson. Neither teacher nor students publicly speak after it has rung; students stand quickly and leave or engage in Post-Lesson activities. JR-6-1 ends with teacher trying to get an answer to a previously asked question, sollicitng a response after the bell has rung; a student answers, and teacher's own response, if there was one, is lost in the Post-Lesson noise. His bid to sustain the Lesson, however briefly, was directed to one student by name; the others ended the Lesson with the bell.

Other teachers are more successful in continuing either the sittype or the thematic development past the bell. In EL, when the bell rings teacher calls out a question which renews a non-science theme (students academic efforts) with which the lesson began, calling for and getting a specific nonverbal response (show of hands), on which he then comments. SST counters a student Bid End which made use of the bell conventions and he completes an interactive and thematic unit. LG successfully sustains the Lesson sittype, but then dismisses the class without trying to continue any part of the prior thematic development. His 'holding the class' merely gave the appearance of a more teacher-controlled ending. It should be noted that many teachers consider the ideal End pattern that in which students ignore the bell and make no Bid End, but sustain 'good' Lesson behavior until teacher Bids End. Thus teachers may hold the class 'on principle' even if they do not want to complete some interactional or thematic unit.

Two cases here approach this 'ideal.' In KF, students do mainly ignore the bell. Teacher uses an indirect Bid End ('Tomorrow we'll begin analyzing ...') and then assigns the homework. This is an instance of a normally pre-Head sittype in post Head position, marked here, as frequently when this occurs after the bell, by haste. In WE also, there is no break-up of the class at the bell (a few close books, one or two stand quietly at their seats) because teacher is in the midst of their last opportunity for review before a test. Indirectly, here, students have Bid Continue, and the teacher does continue the interactive sittype, but not in fact the thematic development (no new review information is covered after the bell), instead he suggests students complete the review on their own from their notes and duplicated notesheets he has just been discussing with them.

In DRS, at the bell, students ask the teacher if he has completed a thematic unit. He replies and Bids End. In NOR, at the bell, it is the teacher again who Bids End.

In BB, RN, and HL, all of which are lessons observed in the same junior high school, the special Quiet Free Time sittype occurs. The teacher ends thematic development before the bell and may have enacted some post-Head sittypes (e.g. assigning homework, answering individual student questions) which were still part of the public Lesson. Teachers then indicate that this special sittype is to follow. In RN, where it is quite long, it is divided into a Quiet Work Time and a Quiet Free Time. The difference appears to be that in the former students should engage in some class-related work, in the latter they need not. In either, students may talk to each other, but must not do so loudly. In general the sittype is a restrained and subdued version of the Post-Lesson situation, except that students may not leave the room and usually, though not necessarily, remain in or near their seats. A detailed videotape analysis would be necessary to define this sittype more closely and will not be done in this report. These three lessons all conclude with clear 'dismissals' that mark the boundary of the Lesson and the true post-Lesson transition.

With regard to teachers' Ending locutions or formulas, the most widely shared feature is an inverse of that for Bid Starts: reference to the past in Bid Starts is replaced by reference to the future in nine of the 14 cases described here, and they are not the same nine that have past-reference in the Bid Starts. In fact, the mere mention of the word 'tomorrow' or an equivalent reference to indexical futurity, made toward the end of the period, can be taken by students as signalling the end of the lesson, even when not so intended by teachers. Bid End locutions of this sort also tend to use solidary 'we' and future tense and to emphasize continuity. The unmarked form might be 'We'll go on with this tomorrow.'

The remaining locutions of dismissal are still more context-dependent for their interpretations - i.e. have meanings in isolation from their situated usages that differ substantially from the meaning of 'dismissal' such as 'Thank you.' Unusually formal and explicit is RN's 'Ladies and gentlemen, the period is officially over, so you may now close your books,' which in fact is not a dismissal. The bell has not yet rung; when it does, students leave.

4.0 Pre-Head Situation types

Between the start of the lesson as a socially focused activity and the start of the new thematic development which participants recognize as the beginning of the Main Lesson ('today's work'), a number of sittypes typically occur. Structurally, these are all optional rather than obligatory elements of the Lesson.

Two interactive sittypes occur, if at all, normally at the very beginning of the lesson and may even preceed the Bid Start: a Classroom Business routine, Taking Attendance, and a Seatwork routine, the Do Now. Teachers often take attendance before the Bid Start or establish the convention that their beginning to call the roll is to be taken as a

Bid Start. Moreover, teachers often take attendance 'by eye' without interacting with students in any obvious way. Thus this routine need not occur as a distinct sittype. When it does so, students are expected to respond to their own names, and occasionally students will supply information about an absent student. Teachers may take attendance orally or silently during the seatwork routine of the Do Now. In this sittype, the teacher writes on the board a task for students to do by working silently and individually at their seats (usually including writing) as soon as the bell rings. Teachers may remind students to begin this task, and this reminder may serve as a Bid Start, as we saw in the last section.

There are other Classroom Business routines which occur, though not necessarily initially, in a pre-Head position. The most common are Announcements(reminders of upcoming school or class events) and Paper Handling, the distribution and collection of papers such as homework, quiz and test papers, book receipts, duplicated materials, etc.

Apart from the Do Now seatwork, none of these normally occupy much time in the Lesson. Most pre-Head time is spent either in Going over Work or in Review. If there has been a Do Now, it will almost invariably be discussed orally, sometimes after students have put samples of their seatwork results on the board. The Going over Work (i.e. of the Do Now seatwork) then immediately follows. Similarly the class may go over the previous, or now due homework. The interaction pattern of Going over Work is generally characterized by External Text Dialog, an interaction pattern in which an external, written text (as opposed to the 'text' of spontaneous public dialog by participants), often something written on the board or questions in the textbook assigned for homework, or such questions on a duplicated sheet, supply questions for teacher-student dialog which are otherwise supplied directly by the teacher as part of the discourse (see section 7.1, Triad Dialog). In this pattern the teacher's usual Evaluation and Elaboration moves become more critical for the course of thematic development than when there is no such external text. (See Chapter 2).

The Review situation may not be easily assignable as clearly belonging to the pre-Head portion or to the Main Lesson, especially if there is no clear metadiscourse signal for the start of the Main Lesson. This is the case in lesson (BB). The Review may be taken as the first episode(s) of the Main Lesson, or be set off from it. Pre-Head Review certainly occurs unambiguously when it is followed by other pre-Head activities, as in lesson (DRS). More often, however, a Review is the last pre-Head or the first Main Lesson sittype. It is usually conducted in the Triad Dialog (or External Text Dialog) interaction pattern (see section 6 below and Chapter 2), but the interactive meaning of the act-types that occur is altered by the Review context. Thus a teacher's question in Review (a Review Question) differs from a Teacher Question in the development of new material because in a Review situation it is assumed that all students should know the answer. The significance of question, answer, and teacher evaluation of answer are all changed by the Review context. One of the functions of teachers' clear marking of the start of the Main Lesson is to shift expectations out of this Review pattern into those appropriate in the development of new thematic material.

Other sittypes may occur in pre-Head position, often assuming a special functional role in the lesson strategy when they do. Teacher Demonstrations of science phenomena and teacher Narratives of stories or anecdotes are intended by some teachers as 'motivations', i.e. to arouse student interest in the lesson's science themes. Sometimes these activities are bracketed apart from the Main Lesson by the metadiscourse signals discussed in the next section. In EL we find a teacher-narrated story used as part of the teacher's strategy for advising the students about success in the course. Students know this sittype as a Lecture, not in the pedagogical sense, but in the parental one; though it may be either a sort of 'pep-talk' if its tone is positive, or a more serious warning or exhortation to do better. It need not include, as it does in EL a Narrative, but when it occurs it is usually in pre-Head position.

For the 14 lessons we have considered so far in this Chapter, the number of lessons in which each of these pre-Head sittypes occurs is:

Review: 9 Do Now: 5 Going-over-work: 5 Business: 10

5.0 Starting the Main Lesson

At the end of section 3.1 we noted that the apparent paradox in a teacher's bid to get the lesson activity started by saying 'before we get started' is resolved by recognizing, as participants do, that following the optional pre-Head sittypes of the Lesson, if these occur, it is expected that the principal teaching business of the Lesson - the Main Lesson, or lesson-proper - will get started. This portion of the Lesson is considered the most important, and, [illegible] for the acknowledged special case of a Review Lesson, it introduces new development of the science themes of the course. Without episodes identifiable as of this kind, the lesson is not ordinarily a 'real lesson' or it is just a 'wasted period'. Even if the Main Lesson episodes should occupy appreciably less than half the total time of the period, this may be seen as unusual enough to require comment or justification (as in RN, SC, and LG).

Co-ordinate with such preview statements as 'before we start', which signal that the episode then commencing is pre-Head, there are signals that teachers give when the Main Lesson actually is beginning. The only common non speech marker of this internal boundary is the teacher's writing of science theme material on the board, often the title or main topic or topic question for the lesson (identified by local convention as the 'Aim'). This act can be the sole signal for the start of the Main Lesson, but it is usually part of a complex including speech signals. The 'Aim' may also be written on the board before or as part of teacher's original Bid Start move, in which case it may be seen retrospectively to have functioned as part of the Main Lesson Start, if no evident pre-Head episodes intervene. If they do, then there will be a different, usually verbal signal for starting the Main Lesson, accompanied by both teacher and student behaviors characteristic of all major boundary points in the Lesson (see Chapter 2).

Looking to the 14 sample lessons examined in this chapter, we find that in 11 the start of the Main Lesson clearly follows one or more pre-Head episodes, which consume anywhere from 3 to 26 minutes of the approximately 40 minute period. The start of the Main Lesson may then be as explicit as 'Let's get to the main question for today (T writes Aim on board)', as in LG and similarly in JR -6 and HL. In such explicit signals it is common to find the word 'today', making a three-part set with the occurence of 'yesterday' and 'tomorrow' in Bid Starts and Ends (cf. LG, JR-6, HL, RN, and NOR). We thus have a lexicosemantic triple contrast corresponding to the major structural boundaries of the Lesson:

'yesterday' -- Start Lesson
'today' -- Start Main Lesson
'tomorrow' -- End Lesson

But the most common cues for the start of the Main Lesson emphasize continuity from the past and may use forms indistinguishable from those of Bid Starts, e.g. 'Yesterday, we talked about, uh, wave motion' (EL, and similarly in WE), though their interactive meaning has shifted with their functional use. Continuity is the dominant metadiscourse theme in implicit signals of Start Main, found in lessons (DRS, EL, LG, SC, KF, NOR, WE, and RN). In some cases there is direct thematic continuity with the previous lesson, but in KF an entirely new topic is begun with the signal: '((Pause)) Now, uh, moving on.' That element of continuity is weak compared to LG's 'OK. ((pause)) Now I want to continue with an idea...' or even DRS's 'Where was I?', but is certainly identifiable as such, especially if we hear it in contrast with the same teacher's 'our next study' a bit later. Even where actual thematic continuity is tenuous, the Main Lesson tends to be announced with an almost ritual-invocation of some ideal of continuity. In this particular instance, by not signalling a major thematic shift at the Main Lesson Start, KF's locution is functioning to build a continuity between topics which students might otherwise see as unrelated here (Balancing Redox Reactions, and Electrochemical Cells). Nor should we overlook the value to teachers for maintaining behavioral control of minimizing thematic discontinuities, which students may take as opportunities for construing the sittype as Liminal (see below, section 8.2) thus introducing discontinuity in the pattern of interactive behavior that weakens teachers' short-term control and at the least delays development of the new themes being introduced. This is a general dilemma of the Start Main Lesson move by teachers: on the one hand they are marking a boundary and a discontinuity, on the other hand they are also seeking to move directly into a new thematic development without an intervening Liminal period. Strong emphasis on continuity in the signal move helps resolve this dilemma.

There are four of these lessons in which it is primarily topic shift alone by which a retrospective boundary for the start of the Main Lesson may be marked. In three (EG, BB, SST) there are review episodes which lead into the teaching of new material with only minor topic-shift episode boundaries. In JR a series of clearly pre-Head activities is followed by a teacher Narrative. The start of the Narrative is a shift of the interaction pattern (to teacher Monolog), and also a thematic topic shift, hence it is at least an episode boundary for participants. But its theme deals with something in everyday life (a movie), with an expected indirect connection to 'science', and it is thus also potentially - when it occurs - and 'actually' when viewed retrospectively, functionally a 'motivation'. The functional category of Motivation, realized in very many different ways in different lessons, is also very often, as here, the initial episode of the Main Lesson, and its occurence serves in effect as the signal of the Main Lesson Start.

6.0 Principal Sittypes of the Main Lesson (I)

The sittypes described in this section *may* occur in pre-Head or post-Head position rather than as structurally integral parts of the Main Lesson, but are treated here because they *do* occur in the Main Lesson. Further details will be found in Chapters 2 and 3.

6.1 *Review* is a *functional* category. A sittype is defined both by its characteristic pattern of social interaction and by the functional meaning of its occurence for participants. Reviews may be accomplished through the patterns of Going over Work (previous section) or the patterns of question-answer-evaluation, as in Triad Dialog or External Text Dialog (next section). Its functional meaning for participants is the recapitulation of thematic systems that have already been developed in some Main Lesson work. Usually that Main Lesson was the previous period's work, or one in the very recent past. In the exceptional case of Review Lessons, before a test, say, several weeks, or even the whole term's work may be drawn upon in the review.

A review of 'today's work' may also occur, either in a clear post-Head position (as in JR and JR-6), or as the closing episode of the Lesson itself (as in SC). Not all Going over Work episodes, but all other realizations of a pre-Head or Head-initial Review tend to have strong thematic continuity with the developments of the upcoming Main Lesson and provide one of the means for building such continuity from lesson to lesson.

The first episode of the Main Lesson in EL-8-2 is a review. The sittype is a Review by Triad Dialog (section 7), cued as such and initiated by the first two utterances following the metadiscourse signal that begins the Main Lesson. The identifying feature is the formula of the teacher's question: 'Can anybody remember...?' indicating a Review and that this is a Review Question functioning within Review Triad Dialog. When one student is unable to answer, the teacher's disappointment is expressed in his reference to 'a question like that', by which he marks the question as asking something every student is expected to know at that point. This illustrates the special difference between just any Teacher Question move and a Review Question. When the teacher does get an answer he accepts as correct, it becomes - after a digression - the first theme of the first episode of 'new developments' in the Main Lesson.

We find the same features in (SC): Start Main Lesson, then Review Question ('Now what did we say about these fossils...?), then in a Negative Evaluation of a Student Answer ('OK, let's remember that...') he develops the reviewed theme as the first formal topic of the Main Lesson, writing the question and answers on the board.

The dimensions of diversity among Reviews seem to be these: their structural and thematic relations to the Main Lesson and the interactional patterns of the sittypes through which they are accomplished. In the latter respect, not only may Reviews use the patterns of Going over Work, and involve or not an External Text of questions or problems, but teachers may or may not utilize opportunities during a Review afforded by comments preparatory to a next question, or elaborating on an already evaluated student answer, to do more or less of the work of the thematic review themselves.

6.2 Teacher Narrative is a cover term for teacher's telling of stories, jokes, anecdotes etc. The interaction pattern is dominantly that of Teacher Monolog with non-verbal behaviors indicating student attention (gaze direction, head nods, smiles etc.) and occasional laughs or side-comments by students. The functional meaning as part of the larger lesson structure is highly context-dependent. Thus the 'fable' told by EL ('snow goose fable') turns out to be part of his Lecture to the class to do better academically, while the 'movie plot' narrated by JR ('The Blob') turns out to have been a Motivation for the discussion of limits on cell size. In EG, the teacher begins a narrative which is then actually told by a student who knows the same story ('starfish story') and which again functions as a Motivation, for a second main topic of the lesson, Asexual Reproduction. In KF there is a brief Narrative, loosely a 'historical account', that functions as part of the transition to the new topic of Electrochemical Cells.

6.3 Demonstration is a common sittype of the Main Lesson. We use the term broadly for the interactionally similar situations in which the teacher exhibits certain objects, including scientific equipment and specimens, and models or other representations of natural phenomena, which students are expected to observe and answer questions about. Though formally the interactional pattern may be little different when the object is a chalk drawing (as in DRS, Episode I), this case in not identified by participants as a

Demonstration. The use of board diagrams, charts, and even models, may not count as a Demonstration, but as part of a Teacher Explanation (see below).

Demonstrations frequently function (in pre-Head or Head-initial position) as Motivations and may then have only slight thematic links to the Main Lesson. They may only offer a pretext of interest in the actual main topic (as in LG, pre-Head). When they do have close thematic relations to the Main Lesson, they may function to: introduce a phenomenon, exemplify a concept, provide a concrete basis for an explanation.

Ten of these 14 lessons contain episodes that are clearly recognizable as Demo's. (This short form is a colloquial usage of the register.) Two others make significant use of charts and the remaining two of board diagrams. Most have only one Demo episode, but four have multiple Demos, one indeed with five distinct Demonstrations. The same Demo may occupy more than one episode, other sittypes intervening.

Specimens (of chemical elements, plants, animals) are presented in DRS and EG for students to observe and compare, illustrating more general phenomena of which they are examples. Simple mechanical systems are presented in EL, JR-6, NOR, and RN to exemplify the principles of more complex systems. In EL a Demo is done just to provide a concrete basis for an explanation (of the transmission of electrical impulses) to help clear up a student's misconception. EG also uses models (of cell division) in a manner that would count for us as a Demo.

In all these Demo episodes, students are questioned about what they see and its meanings. Student participation may be minimal (DRS, LG, JR-6, NOR) or there may be extensive dialogue (EL, KF, RN, SST). In both EG and SST students handle the materials or assist in the Demonstration directly.

6.4 Teacher Explanations and Teacher Summaries are two other sittypes characterized by Teacher Monolog patterns and unintrusive student participation (as with Narratives above). Functionally, participants recognize that the former class includes those action sequences of teachers by which they present an extended interpretative description that develops a lesson theme, and the latter those that recapitulate important thematic developments of preceding episodes in the lesson. Explanations may be conflated with Demos, and both Summaries and Reviews (when conducted as teacher monologs) might be classed together as Teacher Expositions, but we will prefer functionally specific labels for sittypes.

A Teacher-Explanation sittype tends to constitute a brief minimal episode on its own, preceding or insinuating itself into the more prevalent dialogue-based episodes. Explanations tend to be brief (about 100-200 words) and are most frequently found in two functions roles in the prevailing dialogue pattern: a whole Explanation episode may lead up to a Teacher-Question (cf. narrative Motivations), or more often extend or function as the teacher's comment on a Student Answer. Very commonly a Teacher Explanation will develop a logical argument, relating some general principle to the particular themes under discussion, and a logical particle like 'so' is frequently found. The argument is usually simple, consisting of only one or two syllogisms, and the same points are restated, perhaps several times, in similar or slightly different wordings.

More detailed analysis of how Teacher Explanations work interactively and thematically will be found in Chapters 2 and 3. Here we describe some instances to illustrate the type and its common features.

DRS (8L16 - 23: 75 words). The class is going-over the homework in a normal pattern with Teachers Questions read from the External Text.

Following an incomplete, uncertain Student Answer, the teacher provides an answer himself, a statement and explication of 'Hund's rule' in the form of a logical argument that both justifies the rule and states its implications for the original question, 'so that' and 'so' both occur, as do two conditional 'if' clauses, both contrafactual (there is a reductio argument used). The main point is stated twice. The teacher then reads another question from the External Text.

Very similar is SC (6L15-25:120 words) explaining Hutton's principle of uniformitarianism, again in the context of a classroom dialogue, as teacher's commentary following unsatisfactory student answers. The principle is stated, paraphrased, restated and related to the current issue. 'So' occurs twice, and the argument concludes 'And that's how...they prove...'

There are 2 longer Teacher Explanation episodes in EL. The first (7L10-8L1 : 220 words) uses a simple demonstration to aid in explaining a point about the transmission of electrical impulses; The second (8L21-9L16) uses a chalkboard diagram to present a molecular model of sound waves. The first follows teacher's Negative Evaluation of a Student Answer, tries to correct a misconception by creating an analogy to a mechanical Demo, and concludes with a 'so' clause to justify the original Negative Evaluation. The second also creates an analogy, first introducing the analogy features of sound waves through a diagram, describing them with terms familiar from analysis of compression waves on a spring. This explanation leads up to a question and begins (at next higher rank) a new episode of classroom dialog.

Finally, in JR we find another example of the short Teacher Explanation (8L7-26;100 words) on the relative scaling of volume and surface area. It is a response to a student initiative, clarifying part of what the student has been groping towards. Again we find a general principle stated with some paraphrase, applied to the present problem, and worded in a 'so that' form.

Teacher Summaries are fairly common in lessons and also fairly brief. They frequently replace or follow (post-Head) Review episodes, esp. if Student Answers have not been clearly stated or there is little time available for recap by dialog. They may occur at the end of sequences of dialogue development of a theme, as in JR (7L5-9), where the points made by the last few Student Answers are listed as a series in one teacher utterance. In JR (9L28-10L8) a free-wheeling discussion is terminated by teacher's disguising a selective summary of the points already made which he wants to develop further as an answer to a (facetious) Student Question). He then shifts the sittype (10L11-23) by writing his summary on the board, for Ss to copy.

EL (5L6-6L5) also achieves his summary in a mixed mode that begins as monolog, continues the monolog by turning his answer to a Student Question back to his original theme, asking a Review Question to this same purpose, and putting a written formulation of the summary on the board to be copied. He follows with a Review Question on what he's just said and written, and then there is a major episode boundary. In EL we also find (10L28-11L7) a Teacher Summary functioning as a Review of a long dialogue sequence. It is in fact a reprise of the teacher's initial explanation (8L21-9L16), which was developed through the dialogue. It is again followed by a Review Question. (Such post-Summary Review Questions are unusual; normally the Summary, especially if accompanied by written board notes, concludes an episode, and the next episode shifts to a new theme. EL is 'double checking' the students' attentiveness and the unaccustomed procedure seemed disorienting for some students).

6.5 - Copying Notes, Boardwork and Seatwork are the last two major sittypes which do not involve significant class dialog. Both have already been mentioned in discussing other sittypes with which they have close relations.

Copying Notes is a routine in which, normally, the teacher writes at the board (or draws a diagram) and students individually and (ideally) silently copy from the board into their own notebooks. It may closely follow or overlap with a Teacher Summary, the dominant sittype depending on whether teacher and students identify students' principal responsibility as 'copying' or 'listening' to teacher's oral summary and a hybrid of these two sittypes certainly occurs.

In the usual case, T concludes a period of thematic development by summarizing and then writing, while simultaneously orally dictating the notes. Unusual variants include cases where a student is assigned to write something at the board which others are to copy, or to dictate (as in KF). The teacher need not direct students to copy; by convention they will copy anything dictated and nearly anything written. Teachers may say 'Don't copy this' or Don't copy this yet' if they wish to head off the switch to a sittype in which students are not really listening to them and are not expecting dialog. Students may ask "Should we write that?' if they are in doubt or wish to negotiate. The quantity of notes written and copied is often a major arena of covert teacher-student conflict and negotiation, student moves range from groans when teacher begins to write again after having already written 'enough?' to "Do we have to write that?' or "My hand's getting tired.' The strength of the convention which establishes this sittype also leads to the need for the teacher to use a clear boundary cue to end it, e.g. 'Now' or 'O.K.' preceding a bid to resume dialog or regain students primary attention. The end of an episode of this sittype is also negotiable, students often saying 'No. Wait.', when the teacher tries to shift sittype, so as to gain more time to complete their copying (or simply to slow the pace of the lesson.) Teachers recognize this arena of negotiability when they ask 'Everybody got this now?' before continuing. Students also bid to resume dialog by asking questions (or raising hands), and the teacher may decline by continuing to write or asking students to wait ('Hold it a minute.' 'I'll get back to you.' 'Just let me finish this.' etc.)

Copying Notes may precede dialog on its themes (as in EL) as well as follow it (as in JR). Or the dialog may be bracketed, as in LG where the teacher writes a question, has it copied, discusses the question in dialog, then formulates and writes an 'official' answer beneath the question (and similarly in SC). Lessons vary considerably in (1) the portion of time spent in Copying Notes, (2) how uniformly this time is distributed over the lesson, and (3) how long the average and maximum durations of silent writing by the teacher are. Most often these periods of teacher silence last only about 5 seconds, with occasional longer silences of 20-30 seconds. Less experienced teachers, though not only these, may write silently for a full minute or more. Long teacher silences are generally avoided, except during Seatwork, because they permit the sittype to become Liminal (see below).

Boardwork is a sittype in which, at teacher's request, one or usually more students go up to the boards and write or copy specified work of their own; the teacher initiates this, observes its progress, and then regularly proceeds to a Going over Work routine when students have returned to their seats. Students who do not go to the board may have quiet side-conversations, observe the boardwork, consult their own notes, or even copy from the boardwork before it is gone over. The boardwork may present responses to a Do Now, results of homework or Seatwork, or any material of the sort which is the subject of a Going over Work routine. A long Boardwork episode (5 minutes) occurs in KF, where the material is drawn from the Do Now and is gone over in great detail (15 minutes), functioning as a major Review before beginning a new topic. While two students are at the boards, the others complete the Do Now themselves, then observe the boardwork (40%), talk quietly (50%), or write (10%).

The Do Now is the most common, but not the only Seatwork sittype, for Seatwork may occur in the Main Lesson. In all cases, the teacher gives directions, is then silent, and usually circulates among the students, observing their work and perhaps talking with them in non-public voice. The teacher may speak in public voice during Seatwork to amplify the instructions. Students are expected to work individually and usually silently, but they will often question one another, collaborate, or having finished simply talk together on some other topic. They may ask help from the teacher. Mid-lesson Seatwork is found in DRS, where students are instructed to write down electron configurations for three halogens, preparatory to identifying their similarity. In the 3 minutes before teacher resumes the dialog pattern, he clarifies instructions once and interacts individually with several students. Students work individually and there are only a few side-conversations, mainly triggered by interactions with the teacher. At an earlier point in DRS another Seatwork sittype was not successfully initiated by T, leading to a special Disorientation sittype described below. In BB there is a Seatwork episode (4 minutes) in which students are using teacher-prepared materials and a student graph to analyze seismograms. There is more individual student-teacher interaction and far more collaboration among students and confusion about the complex procedures. The midlesson Seatwork activity in HL follows External Text instructions for students to co-ordinate hand motions with and without visual feedback and formulate their interpretation of the outcome.

6.6 Sittypes not analyzed

Before considering the dominant dialog sittypes of the science classroom lesson, we should at least note several usual non-dialog sittypes which are not analyzed in this project. They are excluded because in them there is no participant discourse which could be satisfactorily recorded by the methods used in the project.

Groupwork is a sittype similar to Seatwork, but in which students are expected to collaborate in small groups on a task. During it there is no single focus of interaction for the whole class (cf. Pre-Lesson, Quiet Free Time). There are multiple simultaneous and relatively independent (non-interacting) discourses.

Labwork is interactionally similar to Groupwork (in both some 'groups' may have a single member),and is identified by its use of special materials (other than printed matter) and frequently a special location in the room or in a separate room. There is a borderline type, of course, sometimes called 'classroom lab work' or 'desk lab work'. *Labwork* also normally fills most of the period in which it occurs, whereas Groupwork does so less often, ans Seatwork is usually only a brief portion of the period. In a Lab Lesson there may be Pre-Lab and Post-Lab episodes, including: Preparations (review of concepts, procedures, materials), Getting Set Up (distribution of materials), Discussion (reports of results, discussion of conclusions), and Cleaning Up. Lab lessons are so different from the more usual classroom lessons that they require a special study.

Testing is a sittype in which there is normally no spoken discourse at all. It resembles silent individual seatwork, but tends to occupy longer stretches of time. Short episodes (10-20 minutes) are called 'quizzes', longer ones (30-40 minutes) 'tests.' But though the interactional patterns are alike, the meanings for participants are very different. In Testing students know that their individual work will be evaluated by the teacher and that the evaluation may have consequences of importance. Short tests may be followed by a Going over the Test episode in the same lesson, structurally similar to a Do Now and its follow up, except that there will be a Business routine of collecting the work for evaluation. In SC a 'quiz' paper is distributed late in the period, but by announcing soon after that students may hand it in 'tomorrow,' the teacher allows students to redefine the 'quiz' as homework and the sittype as first Seatwork and then Quiet Free Time.

Media Presentation is a sittype somewhat similar to Demonstration, but in which the teacher usually takes an observer role. The External Text may now entirely control thematic development and there be no dialog or T discourse. Students and teacher watch a sound film, film strip or loop, video display, etc. They may listen to a recording, or perhaps even to teacher or a student reading. This sittype may occupy the whole period or most of it, and may be preceeded and followed by dialog and other episodes. If the teacher retains substantial control of the thematic development, e.g. by stopping the presentation, narrating it, alternating short Media episodes with Dialog episodes to comment on it we would have a variety closer to the Demonstration though for participants these are very different activities, however structurally and functionally similar to the analyst their categories of 'seeing a film,' 'reading,' and having 'a science demo' may seem.

Section 7: Principal Situation-types of the Main Lesson, II: Classroom Dialogue

7.0 Classroom Dialog

In the preceding sections we have identified a number of sittypes whose dominant pattern of social interaction in not that of a dialog between teacher and students. Teacher Narratives, Explanations, and Summaries have a monolog form; the Do Now, Copying Notes, and Seatwork patterns minimize public spoken discourse patterns entirely. Some Business routines may have a monolog character (e.g. announcements, assignments), a limited dialog form (e.g. calling the roll), or be full dialogs (e.g. discussions about class business). Going Over Work and most Review episodes are entirely dialog-based, though they may involve the modifications associated with use of an external text (e.g. reading out questions or answers). Demonstrations usually mix monolog and dialog, with dialog often dominant. Most of the time of the Main Lesson and of any Reviews, Going Over Work, or Demonstrations that precede it, is spent in dialog. Dialog overwhelmingly carries the thematic development of the lesson and defines its short term interactional structure.

Classroom Dialog is a generic category for the interaction patterns of several distinct sittypes. In all of them there are two or more participants in a spoken discourse for which the shared meanings of each speaker's utterances are contextualized by those of at least one of the other speakers. The various Classroom Dialog sittypes differ in the details of their interactional patterns, or participation structures, and in their functional meanings for participants.

There is one 'unmarked' classroom dialog sittype. It occurs most frequently, and its patterns form the background against which the special meanings of the others are 'read'. We will call it Triad Dialog because its minimal form consists of three interactional moves. This pattern may subserve a variety of marked functions (e.g. Review) but its unmarked functional meaning is simply the unmarked, principal function of the Lesson itself for its participants: development of the science themes of the lesson. Triad Dialog is not usually found with other discourse themes (non-science themes).

There are a number of other, less common dialog sittypes. In True Dialog there is a minimal two move structure; it occurs when the teacher is genuinely seeking new information from the students. In Student-initiated Dialog the thematic (as well as the interactional) initative has passed to the student. In Duolog, teacher and just one student engage each other for an extended period in public voice, and the rest of the class may disengage from the lesson, especially if the Duolog does not develop a primary lesson theme. In Teacher-Student Debate one or more students may contest and the teacher defend a position. In Student-Student Discussion two or students may carry on a public dialog in which teacher does not participate or takes only a minor role. In External Text Dialog, usually a variant of the Triad Dialog pattern, some 'text' is treated as a 'voice' in the dialog.

These sittypes may not be named or distinguished, nor their patterns consciously articulated by participants, but participants behave quite differently in these different situation-types. In this section we will examine these interactional patterns and their common meanings and contexts of occurence; in the next two chapters we will study in detail how classroom interaction and thematic development take place in and through them.

7.1 Triad Dialog

Let's look first at a stretch of lesson discourse in which the features of Triad Dialog appear. We will then consider alternative realizations of this pattern that are found elsewhere in the corpus.

At the beginning of DRS, the start process leads at line 16 (page 1) to the teacher's first use of the technical register. There is a diagram in colored chalk on the board showing simple atomic orbitals. Teacher supplies information about the diagram (lines L16-17), then asks a question (L18) about it. This is a regular pattern: questions in Triad Dialog are normally preceded by a Preparation move by the teacher which serves to orient students to the context of the question and/or the type of answer expected. Orientation is often achieved by providing information presumed relevant to constructing an acceptable answer. The structural ties in the triad pattern are one basis for the construction of thematic ties in the discourse. Indeed several related questions may be linked by a common (repeated or unrepeated) Preparation. Preparation moves (TPrep) are optimal, tending to be omitted in the midst of a dialog where the context is otherwise clear, but they are a regular structural feature of Triad Dialog.

Teacher questions (TQ) are the first obligatory move of the triad. They invite a response, but not always thru direct interrogatives. Following a TQ, there is the expectation of a student move, usually a student bid to answer (SBid), realized by the act of 'raising your hand.' Such a bid defers to the authority of the teacher to assign speaking-turns; students do not always want to defer, nor teachers to assign each turn. Thus bids are optional and a bid requirement negotiable. Teachers may also 'call on' a student who has not bid, another assertion of teacher authority that may suceed or fail. This move, with or without a bid, is usually realized by the teacher's calling the name of a student, with or without the rising intonation of a polite request. This is teacher's optimal Nomination move (TNom), and assigns the next speaking turn to the person named, as in line 19.

The most common next move, and the second obligatory move of the triad, is a student answer (SA), line 20. Of course students do not always answer, but onece a TQ has been asked, dialog will usually continue until some relevant SA has been given by some student. A key feature of the SA is that it is recognizably responsive thematically to the question. Note that in line 20 here, it is spoken with questioning intonation, but since it is otherwise just what is expected of an answer it counts, retrospectively at least, as a SA.

In line 21 we have first a repeat of the SA by teacher with declarative intonation. This is this teacher's regular realization of the move Positive Evaluation; it means in effect 'I accept this as a correct answer.' Some evaluation move by teacher (TEval), following SA, is the third obligatory move of the triad. So regular are the expectations of the triad structure that when the expected move is SA, even silence is taken as meaningful (usually as 'Don't know') and when TEval is expected, silence or a null move retrospectively created by, say, a second nomination, will usually in context count as some sort of evaluation of the preceding SA.

Lines 21-22 contain next a teacher Info (teacher informs) move which may be seen both as a comment or an Elaboration on the SA (weakly so here) and as a TPrep for the next TQ (this time a mere ellipsis with rising intonation). There is no Bid/ Nomination routine, merely: TQ/SA/TPosEval, a minimal triad (plus a Tprep). A clear example of the TElab move (teacher elaborates on SA) occurs in line 2L5, which begins with TPos Eval (positive evaluation of SA), then theTElab, then a long Tprep for the next TQ. TElab moves are a symmetric optimal move complementing TPreps. They add information which is thematically more closely linked to the preceding than to the following triad. Naturally there will be cases where an utterance functions in both triads, linking them.

Thus far we have identified Triad Dialog patterns of the form: (Tprep)/TQ/(SBid)(TNom)/SA/TEval/(TElab). Let us consider other options of the triad pattern, move by move.

At the end of his lesson, DRS (rushed by the bell) chains 3 related TQs on one Tprep. 20L22-3 provides orienting information. TQ(1) is at line 26/8, followed by SA, TPosEval (repeats SA loudly). Then TQ(Z) at 28/30, SA, TPosEval; and in the context of two converging thematic series (Cl,Br,I; gas, liquid, solid), teacher's third utterance of line 30 counts as a TQtho its only suggestive surface feature is its lack of full fall intonation. Potentially it could have been a Tprep to be followed by, say, 'and what state of matter is that?' But in the local context, especially once followed by SA (line 31), teacher completes the triad (21L1) with T-Pos Eval, and signals a boundary ('O.R.'), which closes the TQ series, and the Main Lesson. (The move 'TBdry (teacher signals a boundary) is a metadiscourse move which usually frames larger discourse units them a triad and so is not considered part of triad structure.)

That TQs may have no surface features of ordinary questions because thematic and structural cues are sufficient to cue their functional roles is further illustrated at two nearby points in LG. Teacher is drawing a diagram on the board. There is a clear episode boundary at 9L21. There is a triad enacted between 9L21 and 9L27. After a boundary signal, we get TPrep (21-23). Then in lines 23-25 there is a long statement which is responded to as a TQ by SAs (26) and then ratified by a TPosEval (line 27).

The assignment of these functional labels is retrospective. The utterances that count as SAs were not in public voice; there were no bids or nominations. The Pos-Eval is highly indirect. Dynamically, the Eval gave the students' quiet comments the status of public SAs. Together, this established the previous statement's role as TQ, making the initial statement a Tprep. When they occurred, lines 21 et seq. might have been a TExplan (teacher explanation). Teacher could have had something else in mind than 'clouds' and simply ignored the non-public student utterances, or followed them with a TQ (making lines 23-25 just more TPrep). He might have required public bids and a nomination (as he does at 11L15), or just made a nomination, thus reducing the non-public utterances to SBids instead of treating them as SAs.

Again in LG, at 10L13-17, we have a statement functioning as TQ, ratified as such by SBids, a TNom, an SA, and a TPosEval. As in the previous instance, the statement asserts that there is relevant information which students can provide. Even a surface question in a potential TQ slot may not be construed as a TQ if it fails to identify information to be supplied by students. In EL(9L27-10L6), we find first a Tprep, then what should be a TQ. There are no student utterances in public voice. Teacher uses a Prompt move to call for public SAs, but we hear students expressing interactional (not thematic) confusion. Something has gone wrong in the triad structure. Teacher restates his question, now gets several acceptable answers, gives a PosEval. Comparing the two versions of the question it is clear what went wrong: the first version answers itself. There is no missing information for students to supply. While this is not a common error, it is indicative of the underlying formal structure of triad dialogue: it is monolog in disguise. In the initial diagram-review episode of DRS, the use of elliptical questions ('fill the blank') also shows this. Teachers know the answers to their TQs (cf True Dialog below See 7.6). They ask them to engage students in dialog, but it is still teachers who inform students about the subject. As a mode of thematic development the triad structure can be understood as a teacher-monolog in which some key TInform has been transformed into a TQ/SA pair, with TEval required to confirm their equivalence to the 'underlying' TInform, TPrep and TElab are the residual monolog; the bids and nominations regulate interaction but are not part of thematic development. (It is the monolog-dialog relation, not the priority of one or the other structure that I am emphasizing here.)

SAs are not the only things to follow TQs. Ideally TQs are followed by SBids. While these are usually non-verbal (unmarked 'raised hand'), students may also verbalize ('Oh!' 'Ah!' 'I know' cf. LG's mocking this at 6L31) or 'call out' answers either individually or in unison ('chorus answer'). Teacher may treat an answer as an SA by following it with TEval (e.g. DRS 1L23-24) or as an SBid by following it with TNom (even of the same student who answered, cf. DRS 2L2-5. At 11L15, LG asks TQ ('what is a cloud?'), gets called-out answers, makes a metadiscourse move TAdmonish to signal he wants Bids & Noms, repeats TQ, gets Bids, Noms, an SA, and his TPosEval overlaps and cuts-off the SA (cf. DRS 2L5) thus simultaneously acknowledging that the SA is only providing pro-forma the same thematic information as the called-out answers, and enforcing a 'nominations-required' rule. Called-out and 'chorus' answers are most likely when a TQ is considered 'easy' or of lesser importance. Here LG prefaced his TQ with 'and by the way'. In DRS we find chorus answers encouraged by teacher as part of TQ series (18L25-30, 20L26-31), where the later answers in the series are relatively obvious and marked as such by the acceptability of chorus answers.

The TQ usually functions itself as a 'call for bids', but in the absence of bids, teacher may 'prompt' the class ('C'mon' 'It's on the board' 'You should know this'), may nominate a student who has not bid, or may restate the question or state a new question. When a student who did not bid is nominated, some response is expected. Silence may lead to a Tprompt or a restate of the TQ or a new TQ to the same student. Nominated students may decline (SDecline, e.g. 'I don't know') or 'stall' ('What was the question?') or legitimately ask for clarification of the TQ, or simply acknowledge the nomination (cf. LG7L1).

The nomination may be more than just calling a name. The complex nominations in LG (4L2, 6L30-31, 9L5/7) illustrate the metadiscourse character of Noms by combining them with comments on whether or not a student has bid before, teacher's criteria in selecting nominees, etc.

Following an SA, we expect a TEval. If it is a fully positive evaluation, an unqualified acceptance of the SA, it may be followed by a new TQ (or Tprep), or by a TBdry. However a TElab may qualify, modify, or restate an accepted answer. TPosEvals come in unmarked form (e.g. DRS' repeat of answers, LG's 'Thank you', and in marked forms to indicate special praise for the student ('Exactly' or 'That's very good, Erin') if the TQ was difficult or the answer insightful or crucial to the thematic development, or a rare effort by a particular student. In EL (8L17/19) we get first a PosEval of an answer, then a determination of who said it, with a second PosEval to the student.

But SAs may, in terms of the thematic development, be incomplete; or to engage more students in the dialog, a pattern may be used in which several SAs respond to a single TQ. In these cases there is an acknowledgment of each SA by teacher, followed by a new nomination or a restatement of the original TQ. At the end of such a series there will usually be a teacher summary on synthesis monolog, structurally filling a TElab slot. In LG we find this pattern at 1L11-2L3. Teacher follows two SAs with 'Oh-kay' and a further nomination, and a third with a full fall 'O.K.,' which signals a boundary, the end of this SA series. We identify these as 'neutral evaluations' (ToEval); they are non-negative but they do not have the finality of a true PosEval which normally ends a triad and bounds the relevance of the previous TQ. The same pattern occurs in LG9L27-10L6, where the TEval 'perhaps' occurs.

Where an SA is marked as unacceptable by teacher (TNegEval, negative evaluation), one also usually finds that the original TQ remains 'on the floor' and other students may provide answers. Alternatively, teacher may address a new TQ (possibly with Tprep) or just a TInfo to the first student, expecting the student to respond again. This initiates the Duolog pattern of classroom dialog (see 7.3).

Teachers do not usually omit the TEval move (it is structurally obligatory), but if they do (TNullEval) the status of the SA must be determined retroactively and depends on contextual features. In EL at 4L18-20, we find TQ/Nom/SA/TBdry, TMeta, TPrep leading into a normal triad, with a new question and a new respondent. The TNull here counts as PosEval, which is unneeded because the thematic relations expressed by TQ/AQ are identical to those of the previous, normal triad. Again, this is the retrospective view. If teacher had given a TNegEval, it would signal that the TQs of these triads were contrastive rather than equivalent (see thematic development strategies, Ch. 3). A TNullEval may also count as negative, e.g. if teacher's next move is another TQ to the same student (or a Nom of another student. In effect, if the original TQ remains on the floor, given SAs are taken to be defective (wrong or incomplete); if a new TQ is posed, it is assumed the SA(s) are accepted. The exception is when the new TQ does not retroactively terminate the previous triad, but is inserted in it (common in Duolog). If not in Duolog, it is the thematic relation of the questions that signals the status of the dialog. Closely related TQs tend to be inserts. Less closely related TQs start new 'independent' triads. In ambiguous cases, teacher may also signal a boundary (e.g. 'now' in EL4L20), or mark a TQ as an insert (cf. 'by the way' in LG11L11/12.)

For completeness we should note the 'partially positive evaluation' or 'mixed evaluation' (T1/2PosEval) such as 'partially correct' or 'OK. But . . .' in which part of an SA is accepted, part not accepted, or modified in TElab.

7.2 Triad dialog with an 'external text' (XTXT=Dialog)

A common, but significant variation on the Triad Dialog pattern occurs when external text(s) are treated by participants as 'voices' which may fill certain structural roles in the triad. The most common occasion for this is in Going-over-Work, where a set of textbook questions assigned, say, as homework (or for a DeNow), or test questions, pre-empt the thematic initiative of the TQ slot. The teacher, or a student, may read aloud these questions (cf. LG 10L25 - 11L6 where a student reads a TQ written on the board, or 12L19-20 where LG reads his own written TQ, a common practice). Students may also read out SAs they have written or copied in their notes (possibly verbatim what the teacher said earlier in the lesson) or a book. In DRS there is a full quarter of the period spent in this dialog mode, with occasional interludes of normal Triad Dialog.

TPrep tends to be absent, or replaced by orientations (by TMetas, metadiscourse moves) to the external text itself, as 'OK. Number 8.' The TQ is then read in an off-hand way by the teacher, rapidly and with flattened, or sometimes with comically exaggerated intonation. There is a strong register contrast between written style and colloquial style, easily recognized here when hearing something written read aloud. TElab moves now become the teacher's principal means of thematic control and are much more frequent, longer, and thematically less closely bound to the TQ/SA pairs. They are often not thematically close at all to the next external text question (XTXT TQ), and the dialog becomes sharply episodic, with each new XTXT TQ acting as both a thematic and an interactional boundary signal. Since SAs may be read, the teacher may initiate duolog to check students' understanding of what they have said/read.

In metadiscourse, participants may refer to 'he' or 'they' or 'the book' as a speaker in the classroom dialog, or a present participant, as in effect they are (e.g. in DRS 'Why do they ask WHY?').

7.3 Teacher-Student Duologs

Another common variant of the triad pattern occurs when teacher and just one student continue the dialog for longer than a single triad exchange. It is most oftn initiated by teacher's addressing an inserted TQ to a nominated student who has not given an acceptable (or any) SA, or by following a PosEval with a new TQ ('follow-up question'), usually thematically close to the first, to the same student. These tend to be brief (a few triads), in part because other students, excluded from the dialog, may begin to side or to lose interest in the lesson, and teacher strategies for interaction tend to favor widely distributed participation (thus it is rare for the same student to be explicitly nominated twice consecutively, even tho the same students may bid on several consecutive TQs.) We describe here the unmarked Duolog sittype. Teacher and one student may have an extended exchange when student takes the initiative (see 7.5) or challenges teacher (see 7.4) or in a confrontation (see 8). Ordinary duologs seem to occur when teacher is helping student toward an SA, checking to see how student construes his or her own SA, or-least often-when using Duolog for a major thematic development.

In DRS (7L22-8L3) teacher and Natalie alternate speaking turns five times with no other speaker participating. Initiative is always with teacher. A simplest functional analysis of their discourse moves would be:

XTXT TQ (read)/ Nom/ side sequence (SQ clarify/T response)/ SA/ (NullEval=NegEval)/TInform=TPrep/ (TQ), T cues duolog by 'Sh' / SA_2 / TPosEval/ TElab. (TBdry). TQ_2 / Nom/ SA / (NullEval=NegEval) TQ_3, 'check-up'/ SA incomplete/ TInform/ SA incomplete/ TPrompt/ TElab = TInform, T complete SA /.

Natalie gives a wrong answer, T notes its impossibility, she gives a right answer, confirmed by teacher. Teacher held her speaking-turn, signalling Duolog, by shushing other comments before her second SA. So far we have two triads built on one TQ with a side-sequence of clarification (lines 24-25) Teacher signals a boundary ('O.K.'), then checks to see if Natalie understands why her second SA was right, continuing the duolog. Natalie confuses one point of terminology, teacher highlights this, then teacher and Natalie jointly restate her SA correctly. Structurally the special features here are the NullEvals, negative evaluations retroactively implied by the occurence of informing statement and query which lead to revised SAs. The expectation is thus that in duolog, once a TQ is posed, further teacher moves are interpreted as guidance for the student toward an acceptable SA and continue until that answer is stated.

We see this again in LG (11L20-28). The inserted TQ 'What is a cloud' (line 12) had led to called-out answers, rejected by teacher, who repeated the TQ (lines 14/15) and nominated Erin, who answered. Teacher's overlapping and exaggerated TStrongPosEval ('*Exactly*.') marked Erin's answer as merely *proforma* (cf. DRS 2L5). After a brief TElab, he repeats the main TQ that preceded this digression. Then, after bids, he nominates Erin again. This would be quite unusual except that Erin's previous turn, being only a *proforma* contribution, does not count as full participation and perhaps also earns her some claim to make a genuine contribution. Teacher says 'Erin. Go ahead' as if Erin had held the duolog role since he interrupted her 4 lines above. She answers briefly and teacher then asks a follow-up question (implying ^{o}Eval.) Erin expands her answer, teacher asks another follow-up TQ (implying her SA is incomplete); Erin modifies her answer (introducing an element teacher does not want). Teacher overlaps her to correct the new element, and she completes and acceptable SA. The functional analysis might be: (from lines 17-18)

TQ/ TMeta/ Nom/ SA/(^{o}Eval)/ TQ/SA/ (^{o}Eval)/ TQ_2 / SA_2 / T½NegEval)/ TQ_3/ SA_3/ TPos Eval/ TElab. (ending at line 29). A more detailed functional analysis would indicate that, e.g. the TQ in line 26 is also an informing move. The precise interpretation of the NullEvals in duolog may be disputed. Their unmarked significance is that the SA is incomplete (^{o}Eval) or partly defective (½NegEval). What is indisputable is that in duolog students respond to anything short of PosEval (as requiring continued efforts to achieve an acceptable SA, and teacher's moves, whatever their form, serve to signal this and to guide students toward the desired SA.

A rather different kind of duolog occurs in KF (1L6-3L10). It is much longer, carries a major thematic development, and is interrupted by SAs by other students. We no longer have simple unmarked duolog. This is a special sittype, Going-over-Boardwork, conducted as a mixed duolog in which one student has unmarked speaking-turn rights; he is the automatic nominee unless teacher indicates someone else is to answer. The privileged role falls to the student whose boardwork is being discussed.

Teacher asks 'Smiley' to describe his procedures, interrupts once with strong PosEval (line 14) which serves to shorten the description a bit and to mark a key step. At the next full fall intonation, teacher gives another PosEval, segments the procedure, and asks for student's 'next step' (line 18), again giving PosEval (line 24). Teacher now takes thematic control and asks student a specific TQ (2L1-2). SA, PosEval, and TElab now complete a normal triad.

At this point a student question is posed, apparently to Smiley, in public voice, but teacher pre-empts a possible student-student duolog, deflects the SQ and instructs Smiley to continue. He becomes confused when another student interjects a challenge to what he is saying. The challenge is answered by teacher. Teacher poses another specific question (2L19-20) and directs it to the challenger. At 3L3, teacher indicates Smiley is to resume. Teacher interrupts him with another specific question, which he begins to answer when teacher directs it to another student. The duolog is over and Smiley no longer enjoys a privileged speaking role. We can note that at 2L1, TQs to Smiley use pronominal 'you', but at 3L9 the 'you' has been dropped with the end of duolog.

7.4 Teacher-student 'Debates'

Another marked sittype in which the duolog pattern is often found is that of a 'debate' between the teacher and one (or more) students. In this sittype teacher's thematic control is challenged, not at the metadiscourse level (e.g. choice of topic) but as to what is or is not reasonably true within the topic. Debates generally open with a student-initiated challenge (Schall), often an SQ that challenges a previous teacher statement. 'Debate' ensues when the same or another student publicly challenges or continues to question teacher's initial response. This often leads to duolog with non-public support from other students, or several students may side against teacher. (Other student-initiated dialog modes are considered in sec 7.5.) In T-SDebate the triad structure is no longer operative, initiative has passed to students and it is they rather than teacher who must be satisfied (cf. SQ pattern in sec 7.5). Debates tend to be ended by teacher fiat or assertions of superior knowledge, however, rather than by overt student acceptance of teacher's position.

In LG a conceptual difficulty has arisen over whether solar energy is in the form of light or heat and teacher has just written a synthesis of preceding triad dialogue on this point at the board, (12 see silent writing). We are at a probable episode boundary. Teacher now restates the conclusion, as Erin continued to side. He asks if she has a question. Her question (5L20-22) challenges his statement; it is in the form of a logical argument: 'How can X be true (as you say), if Y is true?' In a very common pattern of teacher response when challenged, teacher concedes 'Y' and adds an adversative clause 'but . . .' to make a distinction. Erin's response denies a more basic distinction, teacher contradicts her and gives an example, she turns the example to support her own idea. Teacher now (6L2/4-5) tries to end the debate by assertion, but Erin keeps going, and he reasserts in more peremptory fashion. Erin mocks the emptiness of a mere assertion in the context of the previous logical argument, and teacher responds, again in a fairly common teacher ploy, by invoking and explaining a 'law of nature' (6L14-22), shifting the topic, and writing a new main question at the board, ending the episode. The debate was in pure Duolog form, (one other student aided Erin briefly) with no triadic exchanges. Teacher and Erin alternated speaking turns for several exchanges in which teacher did not control the assignment of turns; Erin took hers 'as-of-right' in this sittype.

The debate in SC (5L1-20) follows a very similar pattern, except that it is not a duolog; 5 students participate. (Note that the classes of LG and SC contain approximately the same students, and SC is a new teacher, whose style owes something to LG's; the lessons take place 4 months apart.) Teacher has just restated the conclusion of a previous discussion in which there was a conceptual confusion. Charley asks a question which directly challenges the conclusion and is backed up by Vito. Teacher concedes the possibility of their alternative, but asserts he is right. Scott offers the view that teacher is only giving a 'theory', but teacher asserts it is 'fact.' Vito and Scott challenge him to defend that assertion, and Rosie joins the fray. Teacher calls for attention and begins a monolog that ends the interactive pattern of the debate. He invokes a general principle, re-establishes his Triad Dialog briefly, then uses it to support his position in the debate. As he ends, he signals a new episode (6L26).

A complex debate which has brief duolog sections occurs in JR (7L13-9L28, 10L24-11L22). Again it begins with a challenge, by Andrew, in the form of a statement which he calls out just after teacher has tried to summarize prior discussion about functional problems of extremely large cells. The challenge offers an alternative to teacher's conclusion. Teacher concedes part of Andrew's claim, and gives a logical argument against the rest (the common Concessive-Adversative pattern: 'X is true, but . . .'). But now another student offers a contrary argument on the same point, teacher asks for clarification and Andrew offers to restate; but the duolog with the second student continues. Teacher offers a response, but now first 'Smartie' and then Andrew, decisively, renew the debate. It is important to note that the public utterances of these students are the plainly audible part of a considerable amount of side-dialog among students over this issue. The three principal student speakers of the debate act in past as 'spokesmen' for others. Andrew has made his point well and teacher now invokes a new general principle, hoping to settle the issue (geometric scaling, 8L17 seq.). But 'Smartie' and two others still press their case. The debate is interrupted by a rare student-initiative: Robert poses the main TQ back to teacher, bidding an end to the debate, but teacher accepts a new argument by Smartie and has a duolog debate with him (9L8-27), which teacher ends only by an explicit metadiscourse move. By that time most of the class had lost interest in the duolog.

Teacher now shifts to monolog, answering the TQ posed back to him by Robert, and writing his summary on the board. But Andrew keeps his hand raised throughout. Finally teacher acknowledges him and a new duolog of the same debate (same thematic issue) begins (10L24). During the duolog with Andrew there is a thematic shift and Smartie re-enters (11L14) and has a very brief duolog with teacher, who again cuts him off (11L22). The next student question is not adversary; after teacher answers it, a new major episode of the lesson begins (12L2).

7.5 Student-initiated Dialog

Teacher-student Debates are the most dramatic sittypes which are initiated by student moves (SChalls) to which teacher responds. There are also student-initiated duologs with teacher which do not have an 'adversary' character. Student initiations which obtain a response from teacher but do not lead to extended exchanges, and student moves to which there is no (overt) response by teacher. These patterns subserve a variety of common and important functions in classroom discourse.

In LG (7L21-8L11), Charley raises his hand in a liminal period (see sec. 8) at the end of an episode while teacher is writing a summary note for that episode on the board. Such boundary times are frequently chosen by students for their initiatives (cf. examples below from EL). Charley's question is of a common and important type in which students mention some phenomenon whose possible relation to the topic under discussion they want to ascertain (cf. Kevin's question at 11:29:40 am in LG on whether chromatography is related to visible spectra colors). Such questions may lead to a 'digression' with extended teacher response on the new theme and/or discussion of it with students, but most often teacher supplies a simple answer or confirmation. Here another student also speaks to this theme, and teacher responds in more detail. At 8L3, teacher makes a regular move of this pattern: following teacher answer to an SQ that required substantive explanation, teacher asks if student is satisfied (cf. DRS 13L23). No overt response by student is needed unless student is not satisfied. Teacher's move implies that student should be satisfied and bids an end to the exchange. Here another student renews the theme, in the form of a comment; Teacher bids strongly for a boundary ('Now.' 8L7) but then responds to the second student, partly to offset some ridicule directed at her comment by other students.

In DRS (12L27 seq), Cheryl's Q also comes at a major episode bdry, but asks for further explanation on previous theme. In response, teacher begins a duolog with her that follows the triad pattern and restores initiative to him in the short run. But Cheryl is not satisfied by the discussion that extends their duolog (BL23-24) and her response to his 'satisfied?' move is a SChall (See sec. 7.4). We now observe the interesting phenomenon of the student-initiative series: once teacher has responded to any student-Inititative, it is likely to be shortly followed by one or more SInits by other students. In DRS, teacher is responding to consecutive S-Inits (see 14L4, 17, 24, 15L10) for several minutes. The long run of S-Inits in the debate sections of JR (most immediately

10L24 seq.) leads finally to the SQ at 11L23 which is not adversary but asks for further explanation on a previous theme and begins a brief duolog with teacher. The SQ was posed during a brief period.

During the HWK review in DRS, a student asks a question at a minor boundary between two XTXT TQs with the common function of asking for a repeat of something already said (5L12). This is given by teacher, elaborating slightly on an original student answer (5L6). Student now asks for a further clarification, including non-verbal description, and we are in the Duolog pattern. A similar sequence occurs earlier in DRS (2L25seq.) when a request for repeat and teacher's exact repeat are followed at teacher's initiative by True Dialog (see sec. 7.6).

Student initiated discussions with teacher do not deal only with thematic content; they are also used to clarify or negotiate the status of 'what is going on'. Thus in DRS at 3L3seq., a student tries to ascertain the status of the series of homework assignments in the class and there is some discussion, partly joking, involving teacher and several students. A more serious clarification of what is going on occurs later on p. 10 of the transcription, beginning with a reprise of the homework series theme just mentioned but then indicating a genuine uncertainty among students as to what the sittype is, what is going on, since teacher appears to have announced a homework assignment and then proceeded to do that assignment himself at the board. Student initiated metadiscourse (10L25-7) clarifies the status of what is happening. (See also in sec. 8 below.) In EL (6L10seq, 12L16seq), twice, at boundary points in the episode structure of the lesson, a student asks for a pass to go to the toilet. In the first instance the student-initiative leads to a duolog, (partly in jest partly in earnest) in which teacher and student negotiate students rights to the pass.

More commonly, however, S-Inits are followed only by direct responses by teacher and not by discussion extending over several speaking-turns, as in debates or the instances just described.

At the end of DRS, students ask if teacher has completed the DEMO episode (21L2); another instance.

Students take the initiative in thematic development principally thru their (functional) questions. The degree of thematic control they exert, or try to, varies considerably from complete accomodation to the existing thematic situation (as when their questions serve to prompt or assist teacher along an anticipated line of development), to those in which they ask for more elaboration on a given theme, to those by which they introduce new thematic material.

Students ask for repetitions of teacher statements (DRS 14L22) or student answers (DRS5L12) that they may not have clearly heard, or they may seek confirmation of the meaning or status of what has been said (e.g. LG 7L18; DRS 12L19+20L13).

Frequently students want more information or further explanation on a point just made and may indicate what particular aspect of the topic they want developed. Thus at DRS 17L22 students simply ask 'Why?' something said is true; but soon after another student asks specifically whether it matters that a diagram is drawn in a particular way (17L27). Teacher's response in the first case keeps to the prior theme; in the second case teacher uses this opportunity to provide new info and introduces an important new theme (18L1-2), but the thematic shift was not created by the SQ here. At DRS 6L26, the SQ does introduce a theme shift, followed-up by teacher, tho it is still basically accomodative to the prior thematic situation.

In KF (2L7) and EL (5L15, 8L25) we find further instances of SQs that ask for further details without directly shifting the theme. KF responds by a metadiscourse move that in effect rules the SQ out of order. EL's replies in both cases continue the previous themes without shift.

An SQ at KF3L19 does introduce new thematic elements, but they are governed by the XTXT of the DoNow the class is going over. In effect, student is reminding teacher of a thematic agenda he himself had set, so student's move really functions as an initiative to control the discourse, rather than introducing new thematic material from the student side of the dialog. It is thus functionally the same as the moves in DRS(5L2-5), which are clearly metadiscourse.

But students do, of course, seek and often succeed in controlling the themes of the dialog. Several examples from DRS will illustrate student thematic initiatives. At 6L14, an SQ (with gestures) pivots on a single feature of the thematic situation (complex muscle co-ordination) making a shift (to which teacher responds) that is so radical that it provokes laughter and a strong teacher boundary move (6L17) to bracket it out and return to the previous thematic agenda. At 7L6 the SQ merely seeks to extend the thematic development to the next element in a standard sequence. This sequence (of atomic orbitals) is being expertly discussed on page 13 of the transcript of DRS, and on page 14 a series of SQs (L5, 17,24) use the sequence again to move the dialog onto new topic areas. In the first instance, teacher repeats the SQ and initiates Triad Dialog. The teacher gives monolog explanations and repeats this form of response for the third SQ, but then initiates a new development (14L18) again in the triad pattern. The shift into Triad Dialog is preceeded by a boundary marker ('O.K?') which also functions as the optional move by which teacher checks whether his response to an SQ has been satisfactory (cf. 13L23). Although teacher moves at the end of the triad dialog (15L6,9) to create a strong boundary (in fact, retrospectively, to start Main Lesson here) and in effect end this long period dominated by student-initiatives (since 12L24), the sittype is liminal and yet another SQ is posed. This time (15L10) the SQ bids a major thematic shift; the 'orbitals sequence' principle is not involved, and only a few long-term thematic elements provide continuity with the previous discourse. Teacher responds by initiating Triad Dialog again. Finally, at 15L20, he starts the Main Lesson.

Just as S-Inits participate in the control of the thematic development of the dialog, they also, usually thru metadiscourse moves, share in control of the process of social interaction in the classroom. In JR (9L3) we find an apparently ordinary SQ, not overtly metadiscourse, but in fact it is a repeat by Robert of a main TQ which has remained 'on the floor' thru the long preceding discussion, directed back at teacher. Thus it functions as a bid to close discussion. In parliamentary language, Robert 'calls the question'. His move in fact succeeds after a brief delay (9L28). We have already cited an instance in DRS (5L2, cf. also 8L8) where student-initiatives keep teacher to a particular agenda. More commonly such student moves seek to control the pacing of the lesson (as in KF at 6L18 and 28 where students seek to slow the dictating of notes and have sentences repeated) or the definition of the sittype and hence what they are expected to do, as in EL, where (2L27) a SQ asks whether material on the board needs to be copied (cf. LG9L17). Teacher responses to such S-Inits may treat them as challenges (EL2L28) or as legitimate requests for clarification of the sittype (LG 9L18). Where such initiatives lead to extended exchanges, there is often a process of negotiation taking place.

Finally, student-initiatives in classroom discourse may not lead to dialog at all; there may be no overt response to them by teacher, their occurrence still contributes to the interactive and thematic situational contexts of the discourse and may be part of larger-scale, longer-term patterns in the discourse.

The dominance of triad dialog and teacher monolog forms in classroom discourse severely restricts student participation, and it is not surprising that students often 'interject' comments (SComms) which have no immediate structural role in a dialog pattern. In KF at 3L23 a student comments, (ironically), 'Oh boy' on teacher's signal that something new and important is about to be developed (3L21-2), but the comment finds no overt response in the public dialog. Frequently the primary context for such comments is a side dialog among students which may be a source of comments or of questions, both of those to which students do not expect a public response by teacher, and of those where they do (e.g. SChalls, SQs). Less than 2 minutes later another student comments, facetiously, on teacher's list of examples of 'agents' - which has violated a science discourse norm (Chap. 4) - by calling for 'more! more!' in this vein. The full functional meaning of those utterances in context is quite complex, but both contribute to longer term patterns in the interpersonal 'tenor' of this class.

In DRS two student comments (3L26, 4L20) on nominations occur. In the first, teacher admonishes a male student for answering when he had nominated a female student, and a second male student makes a joking comment at the expense of the first, magnifying the ridicule inherent in teacher's form of admonition. In the second, teacher nominates a student who had not bid, and another student jokes that this name is rarely heard. Though softened in tone by being made as jokes, both these comments have an underlying element of aggression like those in KF which implied indirect criticism of teacher.

So far, our examples have shown SComms tied to the interactive rather than the thematic context of the discourse. In LG, we find two comments by Rosie (5L6,8L4) that form a pair of parallel monologs with teacher's explanations. They are thematically very closely linked, and create a sense of dialog for that reason, though if they had not occurred, teacher's subsequent discourse would require no change. Any responsiveness is only implicit, but, since Rosie's comments do occur, the full functional meaning of what teacher subsequently says includes its being heard as in some way responsive. The SComm (20L7) of DRS deviates enough from the thematic development of the surrounding teacher monolog that we do not hear responsiveness (cf. the SComm in 20L6 which responds to previous themes but is not itself responded to, even indirectly, because of its extreme specificity), but student is punning on 'rings' and reintroduces this theme (nonverbally, holding up his gold ring at 20L21) to pun again on 'free', which teacher overtly responds to. In these examples SComms have been more co-operative in tenor, but thematically-linked comments can also carry implicit criticism. In LG, during the debate with Erin (see sec. 7.4), Erin has mocked teacher by paraphrasing him (6L11-13). Structurally of course this 'comment' is not an interjection, but part of their duolog. However, at 8L26 another student uses the same mimicing paraphrase pattern to gently mock teacher (and teacher joins the joke by co-opting it into the public discourse). At 12L4 this ironic joking tenor is renewed by an interjection of the sort illustrated from KF (non-thematic, purely interactional).

SComms of these kinds do not wait for liminal, boundary moments to occur, but are interjected directly into on-going discourse in which the speaker has not special speaking rights. It seems very frequent that SComms are, usually indirectly, critical or aggressive in tenor, unless they are purely thematic contributions, and the most frequent target is teacher's use of some discourse strategy which students, by their comments, label as a 'marked' form or use, a discourse move they will not let pass unremarked. Especially interesting are cases where students 'mark' strategies that seem to violate implicit norms of 'serious science discourse'. The 'more! more!' of KF4L21 is one instance, and in the later chapters we will examine a number of other instances (JR: 1L22, 5L18, 7L4; DRS5L2, 7L2, 13L30, 8L4) which constitute enforcement by students of discourse norms. These are rarely responded to by teacher, taking the form of interjected SComms of a critical tenor.

7.6 Other Dialog Sittypes: True Dialog and Cross-Discussion

To round out this swing of dialog patterns and the sittypes in which they occur, we should consider the True Dialog and Cross-Discussion patterns, tho we leave to the next section some of their situational uses. True Dialog contrasts with the far more common Triad Dialog. In True Dialog TQs ask students for information teacher is assumed not to already possess; thus there is no TEval move in this pattern, and no underlying teacher monolog. True Dialog tends to occur when the discourse themes are not those of the science topic of the lesson, but those of the management of social activities of the class, e.g. the Classroom Business sittype. For example, in DRS (2L24-29) teacher is announcing the availability of tutoring. He asks two questions of different students about a particular tutor, they reply, and in the second case teacher adds 'Good,' which is not interpretable here as appraising a correct answer, but expresses teacher's pleasure at the state of affairs indicated by the student's answer. (Pattern: TQ/SA/optional (TComm).)

Cross-Discussion is dialog between students in which teacher is not a constant intermediary. Such dialog is rare as part of the public discourse of the science classroom occuring normally as 'side discussion' in non-public voice (i.e. it is treated as non-public, however loud it may be). It may then give rise to public comments, questions, or other student initiatives. Public cross-discussion is signalled when one student addresses another publicly rather than addressing teacher. If students refer to each other in classroom discourse it is usually in the third person with teacher as the assumed second-person addressee. When one hears a student say 'I think you forgot . . .' in place of (to teacher) 'I think she forgot . . .', Cross Discussion is taking place. Similarly if teacher is referred to in the third person.

Section 8: Lacunae in Lesson Structures

Expectably, the flow of interaction in classrooms has 'gaps' of various kinds. Between the accomplishment of the lessons Start and that of its End, there may be events participants will label as Interruptions, periods of 'waiting', or simply as having nothing to do with the lesson. Where these are of recurring, recognizable types we will label them as sittypes (if they may be prolonged) or as simple act-sequences otherwise. Thus outside Interruptions, Liminal situations, periods of Disorientation, and Confrontations are such special sittypes, while Admonitions are acts, usually by teacher in response to 'disruptive' acts by students (and quite different from the admonitory or exhortatory Lecture Monolog Sittype of Section 4).

8.1 Interruptions

Outside interruptions create gaps in the lesson structure when they occur during periods in which the pattern of interaction requires constant participation by or when they interfere with any other activity. Thus a visitor to the classroom who arrives and leaves during Seatwork or Boardwork may be only a distraction and not interrupt the lesson's structure. But a loud announcement on the P.A. system or a five-bell, will generally halt any other activity. Late arriving students are always a distraction, but cause an interruption only if teacher must suspend an activity to deal with them (as in WE).

Messages to teacher or to students during the period, esp. those which require students to leave the class, commonly interrupt the lesson, as so students requests to leave, tho these may also occur in liminal situations where they are minimally disruptive unless they lead to extended duologs (cf. EL6L10, 12L16).

Teachers often retroactively 'bracket out' an interruption. esp. when they have themselves verbally interrupted the progress of the discourse. Thus in DRS (2L7-9) a noise provokes a comment from teacher, which he directly follows by saying, 'Ron?', a Nomination that restores the Triad Dialog pattern that was in progress before the interruption. His comment had no place in that pattern and the continuation of the pattern (as against, say, beginning again) effectively brackets out the comment. Teacher could also, alternatively, have used his comment as the beginning of a digression on human response to high frequency sound, following it by, say, 'Why?' and so retroactively construing it as a TPrep for this TQ, a side-question interpolated into the discourse (cf. LG11L11-12).

Early on, EL was interrupted by the starting bell of the period and the interruption was prolonged by the late arrival of students with whom teacher has some private (inaudible) negotiation over where they will sit. Another student bids teacher resume the story he had began to tell before the bell, saying 'So he had the goose under his arm, . . .' which would have bracketed the Interrupt by a marked ('So') of the beginning. Teacher deals with another late arrival, and only then resumes with an explicit 'Before we were interrupted . . .'.

BB is interrupted 3 times in the first 10 minutes of the lesson by an aide who needs the keys to a storeroom. (2L15,4L25,7L20). Teacher first gives him a key, then another key, and finally goes himself to unlock it. After the first Interrupt, teacher signals a strong boundary (3L3) 'All right.' and begins a Tprep for a new triad, but he has forgotten that a previous triad was left incomplete. Although he had finished his thematic development prior to the interruption, he had then conflated a TQ with an Admonition to a student. After the interruption the SA takes priority over teacher's initiation of a new triad, and another student clarifies the situation for teacher. Teacher could have bracketed the interruption by repeating the nomination, e.g. 'Well, Mr. D?' The second Interrupt is preceded by a TQ within the context of a duolog. After, teacher signals a boundary 'O.K.', then asks 'Where was I?' (4L25). There is no answer to this 'rhetorical' meta-discourse question (tho if there had been, on the model of the earlier 4L6, the exchange could count as True Dialog, but only a reply to the previous TQ by the privileged student of the duolog. In the last case, teacher is interrupted after he has begun an explanation. He returns, signals not a bdry but a continuative ('Jeah' 7L21) and without other meta-discourse reinitiates his monolog explanation. In general continuatives seem to most effectively bracket interruptions, and full boundary signals are the alternative when teacher has lost track of the situational structure (esp. of the interactional, but also of the thematic situation).

8.2 Liminal Situations & Periods of Disorientation

It is not necessary to look to external Interruptions to find sources for lacunae in the lesson structure. The episode character of that structure itself provides opportunity for a special sittype in which the Lesson as a continuous activity is in a state of suspension. Following major episode boundaries of the lesson, there may not be an immediate beginning of a new episode; between episodes there may occur a period of marking time, of 'waiting for the teacher,' the special Liminal sittype (cf. Victor Turner's use of this term, 1969) in which student frequently initiate either side-discussions or public questions, comments or requests to teacher. In their interaction structure, liminal periods resemble Quiet Free Time (above, section 3.3). Over their duration there is a gradual disappearance of restraints on participant behavior, beginning with the freedom to initiate public dialog without regard to the thematic context of a particular episode, then freedom to side, and ultimately, re-establishment of the full freedom of the Pre-Lesson situation, tho teachers usually resume lesson activities well before that point. A necessary condition for a Liminal situation is that teacher be silent for more than 2 full seconds, ordinarily following the completion of an interactive structural unit, and especially following an episode boundary (i.e. a point of potential thematic closure).

In DRS there are brief liminal periods, of 6 and 5 secs respectively, following the boundaries of the first two episodes, after lines 2L22, 2L29. The short (2 sec.) teacher pauses between discussion of different XTXT TQs in the Going Over Homework episode (e.g. 3L29) are not expected to be liminal because that episode, tho segmented by them, is still in progress and provides a definite agenda for the interaction; there is still a prevailing sittype. The longer 4 and 5 sec pauses at 8L28 are not liminal for the stronger reason that they occur in the midst of a triad (cf. 6 sec non-liminal pause at 15L6). At a clear boundary, no marked pause is needed for a student initiative (e.g. 15L9; or 19L1 where the boundary is mainly thematic), tho at 12L23 we find an SQ following a 4 sec pause and boundary signals for proximate and longer-term episodes (the HWK collection closure ends a parallel activity begun at 10L1). In fact this is the principal internal boundary of the Lesson; in the absence of this and the following SQs, we would have expected teacher to start the Main Lesson as he does do finally at 15L20. Even a brief pause at a major boundary creates conditions favorable to SInits. At 16L19, teacher pauses (5 sec) after having signaled the start of a new activity, but before he actually begins it; a student question occurs here.

Long teacher silences, even when there is a prevailing sittype that does not require teacher's steady verbal participation, particularly in Seatwork and Copying Notes, may lead to liminal situations in which students complete a task, or defer it, while teacher has not yet formally begun a follow-up activity, thus leaving a gap in which (at least some) students are 'waiting' for teacher to continue and begin to side, or perhaps make, first private, and then public voice initiatives in dialog with teacher. This happens in DRS from 15L24 to 16L18 in a long seatwork episode, but not in the episode at 19L18, where a similar seatwork task, which is actually more difficult, is concluded by teacher after a much shorter time.

A rather different phenomenon occurs in the episode in DRS that runs from 10L5 to 11L10. Teacher has asked for homework papers to be collected, signalling by the same utterance a major boundary ending the long Going Over Homework episode. The situation is now of mixed type, between a Business routine and Liminality. Its liminal character is reflected in the siding and an SQ. Teacher responds and then, without comment, writes on the board for 28 seconds. By usual classroom conventions, the sittype should automatically shift from 'Collecting Homework' to Copying Notes, but liminal activities can and do find time in between. There is no further SInit. Teacher now (10L6) very tersely shifts sittype again, to Seatwork. At this point liminality becomes dominant because the sittype is too fluid and teacher's instructions have been inadequate to define what precisely students should be doing. A side-discussion spawns a public exchange with teacher in which it gradually appears (cf. 10L12) that some students have been interpreting the sittype as 'teacher assigns Homework' rather than Seatwork. Teacher tries to clarify this in 10L16-18 and continues to write (28 sec.) But teacher's effort to clarify the definition of task and situation fails because he appears to the students to be engaged in an 'impossible' activity: doing on the board what he has just assigned as homework. As this becomes evident to more and more students, liminality gives way to Disorientation, a special sittype in which participants find they cannot identify what the prevailing situation is. Side-discussions now focus on the problem of 'what's going on?' and give rise to public meta-discourse, expressions of confusion, and direct requests for teacher to explain what he's doing. He does so, very briefly at 10L26-7 and continues to write. After 3/4 of a minute more, students try to re-initiate dialog with teacher, but now on the theme he has defined; Disorientation is ending and the sittype is again a mix of Seatwork Copying Notes and liminal freedom. Teacher adds a few more cues to task and there is a final (29 sec period of silent writing at the board by teacher (11L9) before teacher begins a dialog episode.

8.3 Asides, Admonitions, and Confrontation

Students side-discussions, and even their public SComms (cf. sec. 7.5) often deal with interpersonal relations as well as with lesson themes. Teachers also from time to time speak on-the-side (often in public voice) to students, e.g. to control their behavior, and students may address 'personal' comments to teacher. These exchanges tend to be construed by participants as interpolations into the structure of the lesson, and frequently they have no formal structural ties to the rest of the lesson even as seen by the outside analyst. The most dramatic exchanges constitute the special sittype of the teacher-student Confrontation.

Most teacher Asides are admonitions to individual students in response to some behavior of the student's which teacher wishes to suppress. Usually teacher does not need to describe the offending behavior because students are well aware in most cases of what behaviors are considered by teacher (and other students) to be appropriate or not in given sittypes. Admonitions need not be made as 'asides'; some are directed to the class as a whole, and many are spoken in public voice.

True asides almost invariably function as part of the regulation of interactional behavior thru discourse; they are spoken in non-public voice or otherwise directed solely 'for' a particular student. Thus DRS says 'Did you catch that?' softly and after moving close to student's seat (18L8) to express concern and mark the importance of the previous topic. At 12L1, EL apologizes to a student quietly; at 12L11, LG says 'OK' to a nonverbal, private request by a student; and at 6L3, KF privately consults with a student before publicly nominating her to dictate an answer for the class. Somewhat more public in character, but clearly addressed to individual students and still regulatory in function are teacher moves to defer S-Inits following bids (e.g. JR10L15,19-21; LG8L18-19; SC5L18-19), to prevent distracting behavior (e.g. LG8L21-4) or to break it up (e.g. SC5L5-7).

The most frequent asides, directed to single students but not necessarily in public voice, admonish students for distracting or otherwise inappropriate behavior. The use of public voice is more frequent when teacher is admonishing distracting side talk (and would not be heard by addressees otherwise), or when the admonition also functions as a reminder to the rest of the class of behavioral rules and their enforcement. Public voice, of course, is regularly used to admonish the class as a whole (e.g. DRS 17L30 'Class!', JR11L25 and EL11L25 'Sh! C'mon!') where the unmarked meaning is: end side discussions and listen to me or my nominee. When admonitions are directed to a particular student, that student is often named (esp. if student is talking, to command student's attention). The name may be used alone (es. JR6L17, EL3L4) implying that student's offense is so obvious as not to need specification (usually loud or prolonged siding), although this leaves student the option of replying 'What?' as if the TAdmon had been a TNom, a prelude to dialog. More often the name is accompanied by indirect reference to the 'illicit' activity: 'Frank. *Siddown*.' (JR6L4), 'You *with* us, Andrew?' (EL9L3-5), '*Frank*. Did you hear Monica? (. . .) Be quiet.' (LG2L7-11); Did you hear that Erin? Good. If you weren't shispering to Scott, (. . .)' (LG6L29-30) 'OK, Rosie, don't be a ventriloquist, now.' (LG9L13)'. When teacher can make 'eye contact' with the addressee, the name can be omitted, and only the reference to behavior is verbalized: 'Control yourself' (EL2L21-2) 'Copy this down' (LG7L21). I guess you can see Erin in her riding boots' (LG6L25, has the force of 'Turn around'). Admonitions often rely for their meanings to a very great degree on the interactional context they index, as some of these examples show. When LG calls on a student who has not bid, to answer a main TQ which has been written on the board and read off by teacher, the student replies 'Yessir,' and teacher's next utterance is '*Hi*!'. '*Hi*!' functions, in part, as an admonition, although it is normally a greeting, because greetings presuppose that the addressee is newly present in the interaction, and the situational context makes it inappropriate for this addressee *not* to have been 'present' (i.e. attentive) before this. The class laughs at this exchange. Utterances which are plausibly interpretable as admonitions thus index the behavioral conventions of the classroom, even to such details as the inappropriateness of Larry an raised hand (which is not signalling a Bid) at a moment when SBids have been called for (cf. LG9L9-10).

In an interesting segment of EL (9L16-10L28) we find asides which are structurally and thematically integrated into the public lesson. Teacher creates a 'personalized' tenor by restating a public TQ in whispered asides close to addressees, several times, to different students, students reply by gesture or softly and the class listens to the exchanges (9L18-22). Now teacher frames a new TQ in public voice, is answered in private voice, and teacher asks for a repeat in public voice. Then at 10L14-15, teacher admonishes Ethel, who did not acceptably answer a TQ reviewing material already taught in the lesson, in public voice, and at (10L19) restates the question aside to Fred, then admonishes him for not taking notes in a brief side exchange (10L24-6) in public voice, and again poses the question aside to another student, whose answer he accepts. Because personal asides are usually regulatory or admonitory in character, it may be that the 'personal aside' form of Triad Dialog that uses here may create a 'threatening' as well as a 'personalized' effect. He avoids admonitory asides, in this segment, making them at least structurally a part of his public discourse, though thematically they are still isolated.

Admonitions are not always single speech acts; teachers create admonitory dialogs which engage the addressee more actively. For example, LG has a side-exchange with Frank (2L7-11) in which teacher calls his name, which could stand by itself in the circumstances as an admonition, but teacher immediately follows it with a TQ 'Did you hear Monica?' which would be a true dialog TQ, making 'Frank' merely a pre-nomination. Frank treats it so and replies 'No.' If he had not replied, he would tacitly have accepted teacher's utterance as an admonition. Teacher now asks 'Why not?' as if continuing True Dialog, but he interrupts Frank's answer with first an indirect and then a direct admonition 'Always bored with a good lesson. Be quiet.' The class laughs at this 'entrapment' of Frank.

An admonitory dialog may become a Confrontation. The Confrontation sittype is usually a duolog, with the adversary character of a T-S Debate, but thematically addressed to issues of behavioral control rather than science topics. Teacher and student address each other personally, in 'I-you' forms (which are not usual in Debates.) Not surprisingly, this sittype in any extended form is fairly rare in the project corpus. In two instances, the confrontation is sustained as much more by teacher than by the student; in the third case a defiant student miraculously 'reforms' after teacher has begun to summon a school security guard to have her escorted to the Dean.

EL and Jimmy (who is seated far back in the classroom) takes the initiative, first seeking to claim teacher's attention. Teacher responds not in the usual ways (accept bid, defer) but with a sharp 'No!'. Jimmy wants to negotiate a seat change, saying he can't see from the back. Teacher has moved him because of his siding and refuses to consider a change. Jimmy and teacher argue, teacher with greater (exaggerated?) vehemence.

Finally teacher concedes that they can negotiate after this period, but announces that Jimmy is failing the course and needs to change his behavior to pass. Other students laughed at the initial exchanges, but hen grew much more subdued. When teacher makes the point that Jimmy is failing, another student reacts audibly to teacher's vehemence and his making public something students prefer to keep private.

EL uses boundary signals (2L20-21) to 'bracket out' the confrontation from the rest of the discourse. Such signals frequently follow admonitions and asides, except when these are in non-public voice.

We have now concluded a fairly complete survey of the most frequent and important of the interactional situation-types of the typical classroom science lesson. In the next two chapters we will examine in more detail the interactional and thematic development strategies teacher and students use within these contexts.

CHAPTER 2: STRATEGIES OF SOCIAL INTERACTION AND BEHAVIORAL CONTROL

Sec 1.0. Framework of the Analysis

Once participants, or the analyst, recognize an interactional situation-type the system of options of functional moves provides a structural outline of expectd patterns of interactional behavior. Some key features of these patterns were described in Chapter 1. In this chapter we turn to the strategies by which teacher and students: (1) establish, maintain, and alter the on-going definition of the sittype, and (2) exercise their options, thus filling in the outline and creating from the system 'potential' (as Halliday says) an actual process of interaction. We will rely especially on discussions in the previous chapter of Start and Start Main Lesson strategies (secs. 3, 5), including the use of boundary markers, and student discourse initiatives (sec. 5) and teacher admonitions (sec. 8). We postpone, except where needed to explicate our examples, discussion of thematic development strategies (see Chap. 3), classroom norms and ideologies of 'science' (Chap. 4), and student behavior as an index of communicative engagement.

The maintenance of a sittype, as we have seen already, is necessarily a co-operative accomplishment of teacher and students. In principle, any participant could interrupt or bid to alter the sittype, but normally it is only teachers who do so and do so successfully - i.e. achieve 'ratifying' pattern shifts in other participants' behavior. S-Inits do, however, often succeed in establishing a sittype, maintaining one teacher has bid to end (e.g. continuing a Business episode or adding another SQ in a series), delaying, frustrating, or diverting teacher's efforts to begin one, or (usually at the end of the Lesson) ending one. Teacher and students' interests may be in conflict; the status of moves may be retroactively shifted between prevailing teacher-and student construals, as part of the Negotiation of the definition of the interactional situation.

Even where the definition of sittype or the status of moves is not at stake, a functional analysis of classroom discourse reveals the tactics by which, as move follows move, teacher and students manipulate the options of the sittype's normal interactional pattern to multiply the interactional messages their enactment signifies.

The tactical contexts of a move may be both thematic and interactional, and there arise moments in classroom discourse when the move enacted advances an interactional pattern at the cost of thematic development, or advances thematic development at the cost of the interactional pattern.

The mutual regulation of behavior among classroom participants is not always so implicit or indirect. Specific recurring behaviors by students are responded to by teacher in ways that establish and maintain a system of shared norms of behavior inappropriate to particular classroom contexts. The *kinds* (and occasions) of inappropriate behavior are interactively constituted as violations of classroom behavioral norms by the pattern of teacher responses to particular instances of such behavior. One can reasonably say that the system of norms is constituted thru its 'enforcement,' i.e., mainly thru teacher's admonitions. Students' role in this, apart from occasional participation in enforcement (e.g. SAccusesS', Ss' 'Sh!'), is primarily thru the repeated 'violation' of these norms. Students also help maintain the system of norms by altering behavior when admonished (even if the admonition did not directly mention the behavior or norm involved), or by arguing against an admonition (i.e. against the applicability of a norm, but not against the norm). What is most significant here is that there are innumberable *descriptive* norms of classroom behavior which are not constituted by the 'violation and sanction' process, but merely by the absence of violations. Salient but meaningless behaviors occur no more often in the classroom than elsewhere, situationally 'bizarre' behaviors do not ordinarily occur; these limits of behavioral diversity are taken for granted or pass unnoticed. Teachers do not suddenly speak-in-tongues, nor students begin carpentry projects or do push-ups in the midst of Triad Dialog. What students *do* that is treated as norm-violating is highly regular and predictable, generally limited to a few *kinds* of behavior, that are part of the normal behavioral range of classrooms (see sec. 2.2). Their persistence in a classroom, despite the at least tacit acceptance of the system of norms even by those participants who violate these norms, should lead us to examine their essential functional roles and possible place in a counterfunctional system (see Prolegomena) of both the violation behaviors and the associated violation-sanction pattern.

Despite the necessarily mutual co-regulation of behavior among all participants in a reasonably cohesive social interaction, it is clear that control initiative in classrooms lies mostly with teacher, but it is important to recognize that students control teacher behavior just as much as teachers control students' behavior. This may be clearer if we say that teacher and students enact shared conventions of classroom behavior. Particular kinds of behavior by teacher or by students (norm-violations), and responses to these by the other(s) enact interactional patterns which constitute the system of norms and entrain divergent behavior into regular violation-sanction cycles. Teacher behavior is much more highly stereotyped and predictable than student behavior (at least at the level of functional moves), more conformable to the conventions and less often sanctioned by students. When students enforce norms against teacher openly, these moves may count as a challenge to teacher's competence, or they may simply 'assist' teacher. But more often teachers respond to student behavior (e.g. a general decline of class's attentiveness) not with a specific admonition, but by changing their own behavior pattern (e.g. by ending a duolog). Who is controlling whom? Human social interaction is not often usefully analyzed in simplistic causal terms. Its autoregulatory character suggest teachers cannot easily and successfully introduce structural innovations in these interactional patterns. It should be easier to create new sittypes than to rewrite the rules of existing ones, but alterations in, say, the dominance of Triad Dialog by any means should be difficult. It would be of great interest to have a detailed study of student resistance to teacher innovation.

The following sections of this chapter will examine on some detail the classroom system of behavioral norms and its constitution through violation-sanction exchanges (sec. 2) as well as the various specific tactics teachers and students use in their interactional strategies of mutual behavioral regulation and control.

Sec. 2.0 Violations and Maintenance of Classroom Behavioral Norms.

2.1 Explicit and Implicit Norms.

The norms of classroom behavior are at their most explicit when they are actually stated and rationalized. Almost the *only* occasions on which this occurs are those following norm-violations, and even then it is rare to have the norm made fully explicit, as it is in LG at 13L5-6, where it is spoken in a rather rapid and off-hand manner as in the repetition of a well-known formula, as much to say 'we all know this but I'll say it anyway.' Teacher's strategy of control here, as often, lies in his active presumption that the norm *is* known and the immediate instance only a temporary lapse from usually well-regulated behavior. The extreme form of this strategy occurs in JR (6L17) where teacher only speaks a student's name, presuming student will recognize what he is doing, that it is being admonished, that it is a norm-violation, and what the appropriate behavior should be. Unless students overtly question such admonitions, they are fully co-opted by them. Tho the norm is not mentioned in these instances, the behavior being admonished is recoverable from the situational context, obviously and there is a (sometimes) explicit norm that covers the case. The most implicit norms are those that will probably never be stated explicitly in the classroom.

Consider JR (5L22-23). Both a (contextually) explicit and a deeply implicit norm-violation are relevant contexts for teacher's utterance, which *indexes* a behavior (throwing a wad of paper at another student), *creates* an event of 'admonition' which indirectly invokes the 'surface' norm, and *invokes* a 'deep' norm. The surface norm is that against 'throwing things,' but Larry is not simply admonished for this act. Teacher's 'C'mon' responds to Larry's apparent protest of innocence (nonverbal, inaudible speech), and teacher's assertion that he saw Larry do 'it' serves to disarm Larry's protest. But the final 'Be a little subtle' retroactively adds another dimension of meaning to teacher's assertion. Certainly teacher is not saying that Larry should throw things as long as he is 'subtle' about it. Rather he is reminding Larry (and the class) of, and is actually constituting an interaction, the deeply implicit convention that violations done 'while teacher is looking' may be presumed deliberate challenges to teacher's authority, acts of defiance, and not just lapses from the rules. Being 'subtle' here means avoiding the rashness of such a serious provocation. (As always in microanalysis of social interaction, the force of a meaning is greatly magnified by our focusing on it. In the actual flow of interaction, teacher's admonition is not as intimidating as a full explication of it sounds. See Labov and Fanshel.) Teacher also is being 'a little subtle' here, and indeed we would not expect to hear the 'defiance' norm explicitly articulated under normal classroom conditions at all.

While we have JR's admonition to Larry before us, it is worth ntoing that it interrupts triad dialog, and that the renomination of Ron serves to 'bracket out' the admonition and also to foreclose any response by Larry, thus clinching the 'presumption of acquiescence' tactic and restoring the triad pattern in which teacher is structurally most in control (see sec. 3).

Another deeply implicit convention of classroom social interaction contextualizes the meaning EL makes in his 'little' lecture' (EL2L26-3L4). Teacher has just been drawing a diagram on the board. Student asks if 'we gotta draw that?' It is a common SQ. In LG we can compare 3L18, where teacher simply ignores the question, and 9L17 where he says no. This SQ has two, often concurrent, functions: to clarify whether or not teacher expects them to copy something (the status LG gives the second query), and to register a disinclination to copy (a bid at student control similar to the less frequent 'my hand's getting tired,' which is a weaker bid) In EL the SQ is posed only several seconds after an ironic 'Wow.' comment on what teacher is drawing. Teacher ignored that. But now the SQ is followed by another student's answering 'No' to the SQ, in public voice, together constituting a very strong bid to control what is happening in the classroom EL responds with a brief lecture (he had given a longer lecture on working harder to pass, earlier in this period). The Lecture itself functions as a complex admonition, invoking the surface norm that students should 'copy the notes' on the board (cf. LG 7L21). This norm is explicit at 2L29-3L1. But something more important is implicit in the rest of what teacher says.

At 2L28-9 we find a stressed contrast 'you/me'. This recurs in the following clauses as, in effect 'I write/you copy', the explicit rule. It then recurs again as, effectively, 'I don't control/you control' and embedded within this a sentence from which'I' is conspicuously absent. We can recognize here a paradox, a contradiction, and the action of an ideology. Overtly teacher is saying that students have a choice of whether to obey the explicit norm, and at the same time that 'if you don't get it' 'you'll be taking it' again next term; i.e., if they do not accept the explicit norm, they will fail the course and have to repeat it. Teacher does not say (as he did in the earlier Lecture) 'I will fail you' (which would have preserved the 'me/you' pattern of the monolog) because that would overtly contradict 'I don't control.' Instead, there is a modal shift in the verbs from 'must' to 'will (future' disguising the elements of control, creating an impersonal ('state of things as they are' in which the illusion is fostered that 'I don't control/you control. (cf. EL's use just before of the aside/admonition 'Control yourself' One might call this the 'burocratic' ideology, which maintains a disjunction between our knowledge that the 'state of affairs' (required course, teacher controls 'passing') has been set up by some to control others, and demands that we take responsibility for choices within that given world. It is as much a paradox for teacher as for the students. It will not be made explicit that students (and teachers) should behave as if there was no paradox.

Before surveying the more explicit norms constituted by the violation-sanction routine of the classroom (sec. 2.2), let us consider in their local contexts some examples of this relation between student and teacher behaviors.

In LG we find a number of very indirect admonitions. Consider teacher at 6L25: 'I guess you can see Erin in her riding boots.' How is this remark identifiable as an admonition? What are the relations between its lexical content, a student behavior, and a classroom norm? What contextual features are relevant to its interpretation? First, it is said as an aside to one student. Overtly it speaks of an aspect of that student's current behavior (doing something that enables student to see Erin). Asides which mention or allude to an student behavior are a regular pattern for admonitions, tho they need not be such. What is this student doing? He is half out of his seat, turned to the back of the room, with his head down toward the floor. He may have been picking up his pen, or a piece of paper with a note passed to him. Student makes no defense of his behavior as legitimate. Being 'out of your seat' 'turned around' or simply not in the usual posture of 'paying attention' is a norm-violation, and so the conditions for an admonition are met here. But there is more in the meaning of this event. Teacher has just been writing for a long time at the board, the sittype has beome partly liminal, there has been a lot of siding. Teacher has just (6L24) bid to begin an episode, but students are still talking among themselves. Teacher pauses 4 seconds 'for attention' and most of the siding stops, but one student, near the front, in plain view of teacher is clearly 'not in a position' to pay the full attention teacher is insisting on by his pause. This student becomes the target of teacher's control strategy. The student is male; Erin is an attractive girl in the class who is sitting along the same aisle that student is bent down in and a few rows behind him. Teacher implies that what student is doing is taking sexual pleasure from looking at Erin's boots, i. e. violating a norm not associated with the classroom rules as such. (Again note that microanalysis magnifies the elements of innuendo and embarassment far beyond what quickly and casually passes in a humorous classroom aside.) But it is not this implied norm-violation that teacher is admonishing, but the simpler features of student's behavior that do fall under ordinary classroom conventions.

Another indirect admonition is to Rose in (LG9L13). This occurs in the context of a series of exchanges which does not carrry on thematic development in the lesson but is purely regulatory in character (9L5-14). Teacher begins an episode at 9L4. He asks an easy and obvious question (9L5) and gets several 'called out' answers, i.e. students omit bids. The heard answers are all the same and all supply what teacher's monolog-based triad TQ presupposes. Despite the obvious correctness of the answers, there is no Positive Evaluation by teacher, instead we hear "But I wanna see a hand.' This is a procedural metadiscourse mvoe a Call for Bids, and an admonition that frames 'calling out' as a norm-violation in contrast with 'raising your hand' and 'waiting to be called on' (i.e. nominated). A normal Call for Bids move would be out of place after correct answers, but here functions as an admonition and retroactively retypes those answers as 'unacceptable' (procedurally, not thematically). It is spoken in a 'marked' tone of voice, bracketing it out of the triad pattern, (cf. asides) in its function as admonition. Teacher pauses, then Nominates a student. The student belatedly recognizes the Nomination (more from other student' gaze shift than teacher's words), expresses surprise and begins to decline or defer answering. Student had not bid, and that is not a violation. But in the context of the preceding discourse it is clear that student also had not been 'paying attention', which is. Teacher's admonition of him (9L9-10) carries both the force of that norm-violation and, directly, of a minor violation: having your hand inadvertently raised when bids are called. Of course, it is the inadvertence here which invokes the norm of 'paying attention.' Now teacher nominates a student who has bid, Ian. And Rosie overlaps Ian's answer with her own, which is loudly called out.

Teacher's response is 'I can't hear you, Ian.' which provokes laughter from students and Ian's repeat. Teacher's utterance functions both as a request for repeat and as an admonition of Rosie (who is known in the class for her habit of calling out), the laughter appreciating teacher's double stroke. But teacher now admonishes Rosie by name: 'OK, Rosie, don't be a ventriloquist, now. Thank you.' The closing 'thank you' is a common foreclosure, forestalling student objections to an admonition. But Rosie does then object, provoking more laughter. Finally, thematic development resumes (9L16) and teacher's stress on 'heat' functions as the long-delayed, and her largely proforma TPosEval. Teacher's second admonition of Rosie may have been too subtle for Rosie, but not for the rest of the class. 'Being a ventriloquist' is 'speaking for someone else' as Rosie could be construed as having spoken 'for' Ian in (9L11-12). In any case, teacher calls attention to the behavior being construed as a norm-violation, speaking when someone else is the nominee.

These very indirect markers of violations and norms are only interpretable by reference to theexplicit statement of norms on other occasions, or the more obvious admonitions whose target behaviors can be inferred. Methodologically, we are operating as 'native analysts' whose hypotheses are derived from tacit knowledge of the conventions, and whose evidence, adduced in support of those hypotheses, 'supports' them again in terms of native conventions. Our analysis can be more explicit than the formulations of participants and can identify disjunctions in their accounting practices by framing their 'internal' view of events in a larger external frame, for we are not solely 'natives' but also 'outsiders' whose system of social practices, including the analysis itself, distances us from the participants. If we were 'natives' only to the extent of our observations here, then we would have to explicate the models that suggest our hypotheses, examining their congruence with native models. This makes it easier for the 'outsider analyst' to explicate which wider relations suggest interpretations in particular cases, for our models then are both more explicit and 'smaller'. As native analysts we could, especially if free of native disjunctions, continue such explication almost *ad infinitum*, for every aspect of the embedding culture of an event's meaning (the full meaning system of the culture) contextualizes it. In effect, then, it is only thru *our* participation in the shared Meaning System that we identify the particular connections that we do among behaviors, admonitions, and norms or adduce the evidence we do to justify that these connections are *systematic* for participants and *indicated* in text and context. The 'foreign anthropologist' seeks to do the same through a 'hybridization' of the foreign MS and the target MS, just as the critical 'outsider' native analyst seeks to hybridize the native MS with an external praxis of contextualization that can reveal patterns participants do not ordinarily recognize.

2.2 *Patterns of Student Norm-violations and Teacher Responses*: Inventory and Analysis

In this section we pair student behaviors with the teacher behaviors that function to label them as violations of classroom norms. We will begin with the most common and frequent behavior patterns of this kind and proceed to the less usual ones.

Student side-talk, whether its content is related to lesson themes or not, is the commonest behavior teachers respond to as a norm-violation. Such talk is not in public voice and not directed to teacher (contrasts with SComms). It is usually of more than one or two seconds duration and frequently involves complete exchanges between 2 or more students. Once begun, such side-conversations among the same pairs or groups of students tend to recur during the lesson. Teachers do not admonish all siding. Brief, quiet, non-recurring exchanges are usually ignored. Lengthy, loud, or frequent sides by the same students are usually admonished. Admonitions in public voice, even when directed to single students, often function to control siding generally in the class. At any given moment in most classes there are one or two active sides (including those whose exchanges are non-verbal classes), but it is not uncommon for up to 30-40% of a class to be siding in liminal situations or in situations where students are puzzled or excited about classroom events and consult one another. In such cases admonitions may be 'to the class' rather than to individuals.

In JR, at 2L12-13, student says 'Can't hear 'im' in reference to Andrew's SQ. Teacher has already asked Andrew to repeat, and the reason he was not heard is partly his soft voice, but mostly the siding by students near and behind him. Teacher admonishes this student, not for calling for a repeat or complaining he cannot hear, but for being one of the students siding at the time: 'Yeah, that's because you're talking.' Student's complaint had been disingenuous. Teacher's response is phrased in terms of the common tactic of 'reasoned admonition' that siding interferes with hearing classroom dialog, for others as well as for those who side. We find this tactic in LG (2L7-11) and (4L29-5L1). In both cases LG asks the students being admonished if they heard what another student has just said. The students reply as if the sittype were True Dialog, but teacher then retroactively establishes the event as an admonition. In the second case he said: 'if you weren't whispering to Scott, you mighta heard her in the first place,' the last part said very loudly, making the violation explicit and stressing Scott's name, including him in the admonition for siding. In the first case he had said: 'Ah. Always bored with a good lesson. Be quiet.' The abrupt command identifies the violation by naming its 'opposite', but the preceding comment alludes to a usually implicit norm: that siding is disrespectful to teacher. It also invokes a very deep theme of classroom culture: whether teacher's teaching is 'good' or not. Imagine the tone of voice in which a teacher might say to a restless class, 'Am I boring you?' In the scale of admonitions, this form would carry a strong threat, touching an obviously sensitive issue. We will see below that allusions to teacher's competence are a powerful tactic of student control.

Talking is the unmarked norm-violation. At 6L17, JR simply interpolates a peremptory 'Andrew.' in the midst of his summarizing monolog. At 3L4, EL similarly says (aside) as he speaks, 'Felicia please. Felicia.' Andrew & Felicia were siding. So also to the class as a whole. It is excessive siging that is admonished by DRS' 'Class.' (17L30), JR's 'Sh! C'mon!' (11L25), and EL's 'Sh! C'mon' (11L11). Very often teacher need only stare hard at siding students to admonish them (cf. the deep norm invoked at JR5L23), or pause 'significantly' for more than 2 seconds while looking directly at the class, for siding to diminish or end, in these classes.

Side-talk normally occurs only between students sitting adjacent to one another (nearest neighbor configurations) and only rarely across longer distances, since this would require public voice. Longer-distance communication may occur by gestures and 'sign language' or by note-passing, itself a violation, tho a relatively rare one, often undetected or ignored by teacher.

These patterns of unofficial or private cross-communication among students are so pervasive in lessons, despite sanctions, that we should assume they serve essential functions in the lesson. It is frequently observed in the field-notes of the project that student initiatives come from students who have just been siding. A significant, if unknown and variable, fraction of side exchanges are less-related. The highly constrained official pseudo-dialog of the classroom makes it difficult for students to 'think aloud' thru dialog, i.e. to verbally formulate and check for social acceptability what they wish to say. When anything said or indirectly constructed (e.g. sittype status) by teacher is missed, asking teacher for clarification can be an admission of inattention and invite admonition rather than information. Fellow students are a safer source of that information. Apart from the practical concern for mutual intelligibility of public discourse in a 'noisy' environment, and the ritual respect shown to teacher by student attentiveness, the constantly violated norm against siding reflects, I believe, a cultural ideology that learning and achievement are _individual_ rather than _social_ accomplishments, for which individuals are responsible, and which reflect _individual_ merit, thus providing a basis for distribution of rewards and privileges. A classroom in which there was no siding, (and little or no public cross discussion) would in this respect be a norm-conforming one, but its atmosphere would be 'intellectually dead' by the culture's own standards (an instance of ideological disjunction), and we would expect fewer successful student initiatives. Full norm-conformity would be counter-productive, perhaps even favoring challenges to the ideology which the norms serve, but the prevailing pattern is much more stable: the 'violations' provide flexibility in the system, while the cycle of violation and admonition maintains the system of norms. One recognizes here a general principle of cultural stability, the 'invisible hypocrisy' of social systems whose ideologies are stable only so long as they are 'enforced' but not adhered to, 'normative' but not the observed 'norm.' Only the selective blindness of disjunctions in the Meaning System allows such contradictions to selective envelop participants unnoticed.

We should add of course that the prevailing situation in classrooms, in which students do share with each other as part of the social processes of learning, is distorted by the maintenance of the ideology and its norms, from the free discussion that by our culture's own standards would be a sign of an intellectually exciting classroom into a sort of clandestine and furtive communication, what KF(2L12c-d) calls in admonishing it: 'the guerilla talking.'

'Calling out.' Not only should students not talk to each other during the lesson, but when they join the public dialog it should only be after bid and nomination. Students break this rule by answering publicly immediately after a TQ, preempting the bid and nomination procedure. We have seen LG respond to this (9L6,13L5-5) explicitly. SC(2L6) merely says 'Don't call out!' One student may so answer, and even then teacher may request a proforma repeat (DRS2L2-5, without admonition), or another student may answer (cf. LG9L10-13). When this happens in DRS (3L23-5), teacher admonishes the (male) student who answered overlapping the nominee (Janice): 'Your name Janice? Is your name Janice?' Repeating it to force the presumably humiliating public 'No', rubbed in by another student's comment. (Note that a fully explicated microanalysis here would have to consider how sex-stereotyping and the horror of male homosexuality operate in our culture primarily as a system of control of the behavior of the nonhomosexual male majority.) Occasionally teachers will make it explicit that it is not just to insure orderly discussion that this rule exists; they may say 'If you don't raise your hand, I can't give you credit' for a correct answer; i.e. the norm again sustains an ideology of *individual* achievement in what is an essentially *social* process. Teachers do not always admonish 'calling out.' At LG5L10-15, *many* students call out answers to an easy, previously answered, question. Teacher accepts these answers but notices that Rosie is bidding; he nominates her, she repeats the correct answer, and teacher gives a Positive Evaluation. The class laughs at this, but the ideology has been reinforced by it. In this case perhaps, and certainly in others, teachers seem to invite, and often accept, Chorus Answers, although these are equally often admonished (more so when they are not fully synchronized or originate with only a few students, cf. LG11L14 and LG at 11:27:40. When rushed for time, or when teacher assumes everyone knows the answer but wishes to maintain the facade of dialog, chorus answers are expected and accepted. (cf. DRS18L30 and 20L8-3).

Not *Paying attention* is a generic violation that applies to a range of less well-defined student behaviors. In EL we find (9L3-5): 'You *with* us, Andrew?' addressed to a student who *had* been siding, but was not at the time. His gaze direction may have been other than to teacher, board, or his notes (see Chap. 5) e.g. 'looking out the window' or 'staring off into space.' At 10L14-15, EL says to an student who has just answered unacceptably a TQ that reviewed what had been discussed, just before: "Now if you didn't listen to what we did before,-you were off in a fog someplace, right?" Normally it is only when students have failed to respond acceptably that they are admonished, directly or indirectly, for not paying attention. Teachers will often deliberately nominate an apparently inattentive student who had not bid, to create an opportunity for the admonition. AL 6L25-7L7, we find LG, having just admonished the student who was bent down into the aisle (see above) as part of his efforts to recover student attention after the previous liminal period, introducing a main TQ which is written on the board and which he has just read aloud. He then poses the TQ indirectly, without repeating it again, and announces that he will nominate someone new (who may not have bid). He playfully hesitates in his choice and names Ian. Ian's response does not conform to the status of the triad dialog (it would be appropriate only if it and the nomination had preceeded the TQ. Teacher's 'Hi!' admonishes the inattention thus exposed (see analysis above, sec. 8.3) Ian quickly identifies that there was a TQ and asks for a repeat, but this exposes his inattention again, and teacher's reply 'It's up there' answers him and admonishes his inattention again. Ian reads the question and gives a plausible answer.

Teqcher's Negative Evaluation surprises him, and in context the TNegEval and the subsequent nomination and success of David imply strongly that the answer was obvious, further indirectly admonishing Ian's inattentiveness to the strong clues to the answer that had already been given (6L21-22,28-30).

Not taking notes is another moderately frequent norm violation. Again this is likely to be discovered only when student has failed, especially in a review situation. In EL (10L19-26), Fred has failed to answer a question recently covered in the discussion. Teacher says: 'Let me see your notes please. You takin' notes now, Fred?' This functions retroactively as an admonition when it appears that Fred is not taking notes. Moreover, Fred has a double violation here: he is 'unprepared', lacking in this case a pen. (cf. DRS 16L3-4, where student has not brought a charge he is expected to have). LG more simply admonishes a student aside (7L21), 'Copy this'.

Being late is the last reasonably frequent norm-violation. Teachers vary greatly in the extent of their comments on late arrivals. School procedures also differ. In WE there are an unusual number of late arrivals, all of whom are admonished in varying degrees, and two of whom are sent out again by teacher to obtain 'passes.' One student takes this demand by teacher as a personal reflection on the honesty of his explanation for why he is late (11:28:46), while the other apparently interprets it, as teacher does, as an impersonal, burocratic procedure.

Other relatively infrequent, norm-violations include: being '*turned around*' (LG6L25), being '*out of your seat*' (JR6L4), '*throwing things*' (JR5L22-23), '*making noise*' (other than talking, cf. EL at 1:43:22 admonishing a student with a hand-buzzer). There are also a large number of often inobtrusive activities students may engage in which constitute norm-violations because they are not usual lesson activities and give the appearance of inattention (and disrespect), such as eating, reading comic books (or anything other than the text or assigned materials, doing homework from another class (or even this class) etc. And there are actions which violate norms not constitutive of classroom interaction as such, such as fighting, annoying other students, writing on desks, etc.

The maintenance of behavioral norms is only one, if perhaps the most immediately evident, aspect of the regulation of classroom social interaction by participants. In the next section we will look more closely at the tactics of mutual behavioral control and other more general strategies of social interaction.

Sec. 3.0 *Interactional Strategies and the Regulation of Social Behavior*

As we proceed now to examine interactional strategies in greater detail, we will need to analyze how they operate in their discourse contexts as well as identify their most common and important types. We will first survey two broad classes of strategies: those whose tactics utilize 'structural' features o regulate interaction and those which manipulate thematic development. We will add some comments on the strategies most commonly employed by students and then analyze in detail several lesson episodes where these strategies can be seen at work. (We postpone to Chap. 4 a fuller consideration of strategies by which the regulation of the 'stylistic' norms of science classroom discourse is accomplished.)

3.1. 'Structural'tactics.

In Chap. 1 we examined the patterns of social interaction of various classroom sittypes in terms of the structure of functional moves that helped constitute them. Choice among options available within structurally regular patterns create considerable scope for manipulation of the interaction. Teacher moves bid the start and end of sittypes and episodes; student moves also bid such starts, or defer them, and (rarely) bid to end them (cf. JR5L18,7L4). With the acquiesence or active ratification of other participants, such moves create expectations of appropriate behavior and act-type sequences. The pervasive Triad Dialog pattern gives teacher many opportunities to control interaction, providing for control of initiative and key turns, and an indirect control thru TEvaluations. In the XTXT Dialog pattern, teacher may lose control of initiatives and students hold teacher to the XTXT agenda, or teacher may use the XTXT as a pretext of control. Teachers also have a story, structurally based control in sittypes such as Copying Notes which students may oppose by redefining that sittype as liminal. In Teacher-Student Duologs, other students are only weakly controlled by (i.e. likely to be responsive to) teacher's behavior. In T-S Debates, initiative and control often pass to students.

Consider first regulation of the start and end of lesson episodes. While these may reflect a primary concern with thematic development (e.g. introduction of a new theme), they still regulate the pacing of the lesson (cf. Bernstein's emphasis on pacing), and may be used to control student (or teacher) behavior. Students initiate episodes most commonly thru SQs and SChalls; teachers use boundary markers, directives, regulatory metadiscourse, and (usually together with one of the preceeding) the retroactively identifiable first move of a particular sittype pattern. Teachers end episodes mainly with boundary markers, pauses which trigger a liminal period), and occasionally explicit meta-discourse. Students rarely end even the episodes they have begun. Whether teachers have the 'last word' or not, they select the End routine (e.g. a check-up on the TA to a SQ) and, except after the bell, only their bids to end are successful. This symmetry between teacher and students is one of the clearest indices not only of the power relations of the classroom, but of the ends to which that power is used: to sustain interaction. What is the 'message' of this discourse asymmetry? If initiation is shared (albeit unequally) but not termination, it would seem that the underlying assumption is that students may not want interaction to continue and cannot be given this option. Behavioral norm-violations that represent disengagement from the lesson are student's 'unofficial' alternatives. (It is consistent with this interpretation that students may sustain an episode or sittype aginst teacher's bid to end it.)

We can followin in DRS the major episode Start and End moves (excluding the Lesson Start and End). Teacher ends the first episode with meta-discourse, labeling the preceding episode and distancing it, followed by a 6 second pause (which students make a liminal period). He begins the next by an announcement (2L24) which is also a theme-shift, and ends with a 5 sec pause. The next begins with a directive (3L1), which indiates a regular lesson activity (Gong Over Homework.) A SQ initiates a metadiscourse dialog on the Homework, which teacher terminates by a boundary marker ('O.K.' 3L11), resuming the Going Over Homework sittype by using an XTXT initiative (see below.) We will discuss control in the XTXT Dialog pattern separately below. The next sittype (Collecting Papers) begins with a directive (10L1). Following an SQ and his announcement-answer, teacher begins to write at the board. As discussed in Chap. 1 (sec 8.2), teachers move to define the sittype (10L6) fails. Disorientation is resolve by moves defining the sittype as Seatwork (10L26-7, 11L8-9), the first is procedural metadiscourse, the second is a directive. (Directives are the usual initiatingmove for Seatwork.) At 11L10, teacher uses only a boundary marker ('O.K.') and proceeds into Going Over Seatwork. Another boundary spiral (12L16) marks the return to Assigning Homework (already begun in 10L6-15), which is ended by a 4 sec pause and a boundary signal (12L3), leaving the only 'open agenda' the Homework Collection initiated at 10L1, which teacher effectively ends here with a procedural meta.

A series of S-Inits (SQs at 12L24, 14L4-5, 14L17, 14L24, 15L10; SChall at 13L24) now effectively controls the interaction. After responding to the first SQ, teacher uses a special bid-end move of this pattern (teacher check-up) to check whether student is satisfied (13L6). Teacher then initiates Triad Dialog. He repeats the teacher Check-up, but is answered by SChall. He makes no boundary move at the end of his response; another SQ is posed. At the end of his response this time (14L15-16) he uses a meta which appears to Bid End on this thematic line of SQs, but another such SQ is posed anyway. For the first time he does not use dialog in his response, making it brief, but there is no overt Bid End and there is then still another SQ. Teacher responds and shifts into Triad Dialog. He now clearly Bids End (15L6-9) by a boundary signal, thematic closures, and then another boundary signal. But still another SQ is posed, responded to in Triad Dialog, and finally at 15L18-20, teacher successfully ends the SQ/TA pattern and starts the Main Lesson with a new seatwork episode, when he says 'Very good.' which evaluates segments, and terminates the SQ episode (15L10-18). It is not a TPosEval, which preceds it. He adds 'Where was I?' a continuative that signals Start Main, then 'Chemical Periodicity. Number 2.' another continuative, which names this Main Lesson and finally 'Please notate...', the directive for Seatwork.

This Seatwork period is terminated at 16L18 by a boundary signal ('All right.') and a Bid Start (procedural meta) for the usual follow-up of Going Over Seatwork. Its Triad Dialog is interrupted by SQs at 17L22&27, resumes by TQ at 18L5. At 17L13-14, Jeff interrupts teacher, just after a continuative 'Now' that signals a thematic progression, to announce 'I'm getting a pattern.' Teacher initiates a brief True Dialog, then extends it to the class as Triad Dialog (no Norms, Chrous answers). Teacher signals a thematic epiosode boundary at 19L1 by 'Isn't that amazing!' We note that teacher has used the distancing effect of 'that' several times to signal closure in this lesson. At this point another SQ is posed, and teacher's response to it includes dialog and then (19L18) a directive to initiate (very brief) seatwork, with immediate dialog follow up. He ends this episode (begun by the SQ) with a boundary signal ('Alright' at 20L20) and then just about initiates a Demo (by displaying specimens and identifying them) when the bell rings.

DRS did not end any episodes by 'cutting off' students, but this option certainly exists. For example JR cuts off an SChall that is extending a theme far beyond what he wants to develop for the lesson (9L24-7), by interrupting student and then explicitly saying (meta) 'Well let's not get into...' that issue. He then begins a TExplan disguised as a TA to an earlier, deferred SQ (see sec. 3.4 below for details). By referring directly to that SQ he creates a discontinuity in the dialog in relation to the SQ he has ruled 'out of order', creating an (internal) episode boundary. At (11L21-2) JR cuts this student off again with 'Uh...you're getting a little too...picky.' After a 4 sec. pause, he recognizes another SQ. SC terminates dialog in two cases (3L19-20 and 6L13) where SAs have diverged from his preferred line of thematic development. In the first case he says the lesson is 'gettin' off the track' and introduces a TEplan as his 'helping out a little'. In the second, he interrupts an extended SA, uses a boundary signal and gives a TExplan answering his own original TQ.

A special tactic of structural control by shifting sittype is teacher's use of the act of writing at the board to initiate Copy Notes, While the normal occurrence of this sittype is governed by thematic criteria, teachers do use it to control interaction. When the thematic divergence of SQs, SComms, and SChalls threatens orderly thematic development in the lesson, JR follows his TExplan (9L28 et seq.) by writing at the bd (10L10-23) both preempting such divergence in general and deferring one student's bid in particular. Later in the lesson (11:33:01) as he writes he admonishes a talking student to copy merely by saying 'So another addition, Fernando, is...' as he writes it. It is folk wisdom among teachers that students may be 'kept quiet' by sustaining the Copying Notes sittype, if necessary with an implicit threat such as "This is gonna be on the test, so you'd better copy it' (cf. EL3L2-3). In practice, long periods of Copying Notes tend to become liminal, tho a teacher who can observe students as he writes or after can readily detect students who are not conforming to this sittype's behavioral norms.

The system of options available in dialog sittypes (esp. Triad Dialog, XTXT Dialog, and T-S Debates) supports an interesting range of tactics of structural control. When initiative thru Triad Dialog (cf. DRS at 18L22 after Jeff's initiative, at 19L12 after S-Init on teacher's are highly successful in asserting their prerogatives, e.g. over speaking rights. For example, in DRS at 3L24 when another student answers after teacher has nominated Janice, he asks 'Your name Janice?' repeats this and student finally answers 'No.', yielding to teacher. At 11L22, when an ambiguous nomination is clarified DRS as 'Frank F.', the other Frank, who had answered retroactively 'out of turn', apologizes 'Sorry.' In a less co-operative class, EL also specifies which 'Gary' he means (6L25) not because another has answered, but to insist on a response from the intended student. Student responds 'What?!' and teacher repeats the question, eventually shifting to another nominee. When a student declines to answer, teacher may 'prompt' the student and directly or indirectly insist on an answer (e.g. DRS13L18, LG-12L23-4, BB2L6). When students do answer, teachers may interrupt and add to or modify what they say (e.g. DRS 9L12-19, SC6L9-15), tho this is more commonly done by TElab moves. In DRS (2L2-5), a student is nominated after she has answered. This has the effect of reducing the 'official' status of her answer (retroactively) to a quasi-bid, getting her to repeat the answer, which teacher confirms as merely a pro forma repitition by overlapping his TPosEval with it (cf. LG11L14-16). A moment later, however, (2L13-16) DRS the teacher-dominated pattern of bids and nominations to thematic development ('getting the answer' somehow) by seizing on a called-out answer, trying to identify its author, and confirming it by TPosEval, TElab. In both these cases (see sec. 4 for details) teacher's choice of options tends to ratify retrospectively one or another of two conflicting constructions of what the actual status of the preceding student and teacher moves 'is' within the triad pattern.

While the control of speaking rights and the presumption of response to a question are not changed when the question exists as an 'external test' rather than being constructed in teacher's initiating move, teacher's monopoly of initiative is broken, and teacher's strategies change. In DRS the textbook questions assigned for homework may be read by teacher in the structural place of a TQ, and teacher may declare boundaries by use of the number (or letter) of the textbook question. At 6L16, teacher uses this option to terminate a student-initiated 'digression.' Thus, tho teacher no longer has thematic control of the initiatry questions, he can still control the pacing and interactional definition of situation deciding when they will be posed. In 4L26-5L12, we find teacher prompting his nominee for an XTXT TQ when several students enforce the norm of following the XTXT sequence on teacher. At 5L5 a S invokes the letter of the 'skipped' question and teacher drops his nascent dialog with Josephine, reads the question aloud, nominates Ron, and approves his SA, then preselects Josephine, re-reads the question, and continues with her through to an acceptable answer. In KF (3L19-20) where the XTXT is a set of Do Now questions written on the board by teacher, a student again invokes the XTXT to initiate dialog. Teacher's thematic control (see Chap. 3) can be exercised in XTXT Dialog only through the TElab move, which becomes more elaborate and frequent than in ordinary Triad Dialog. But teachers regain full interactional as well as thematic control only when they digress from the XTXT as DRS does at 5L22-6L6, 6L7-13, 9L20-30. Students initiate dialog in this period at 5L12 (which leads to teacher's first digression), 6L13 (which teacher ends by invoking number '10'), 6L26 (leading to a stylistic norm enforcement by students against teacher) and the contiguous exchange from 7L6 (ended by teacher's reading the next question), and 8L8 (students read an ancillary XTXT Q 'Why?', which teacher repeats as TQ to solicit bids).

In SC we find teacher writing his TQs on the board, numbering them, and then treating them as XTXT TQs for the purposes of dialog (e.g., 3L30-4L6).

The complex interactional strategies of the teacher-student debate, where student initiatives dominate the interaction will be analyzed in sec. 4 below.

Of the structure-based tactics of control, we should mention finally two types which are not specific to the underlying patterns of particular sittypes. Teachers bid to and do successfully interrupt students far more often than students do to teachers. We have encountered numerous examples of teacher interrupting already, reflecting teachers absolute presumption of residual speaking rights (cf. LG2L7-1Z, KF1L14, SC6L12-13, JR9L26). Student's interruptions of teacher may fail interactionally if teacher does not respond to them (cf. JR10L3-5), but they do sometimes succeed (as in DRS17L3 where an SChall is invokes the theme of a prior dialog between teacher and that student). Another common structure-based tactic of teachers, occasionally employed by students, is control through pacing. Most teacher pacing is indirectly accomplished through the rate of thematic development, how frequently teacher introduces new themes or develops additional relations of a thematic system. Accelerating the pace of a lesson, or creating time limits for discussion of a theme, even implicitly, may inhibit divergent S-Inits or provide a pretext for teacher's denying speaking rights to S-Inits or limiting the scope of

TEplans or responses to SQs. In LG at 1L8-11, teacher emphasizes at the start of the Main Lesson that he might not be able to finish by the end of the period, creating some sense of the 'pressure of time.' At 7L19-20 he even less directly refers to a thematic goal he wants to get to 'in a minute.' In fact he never reaches this goal and does not achieve his planned thematic completion before the end of the period. After 10 minutes of Seatwork, KF 'hurries' students into attentiveness to Going Over the Do Now (1L1-3) by announcing that they must soon move on to a new topic (which actually begins 16 minutes later, when there is only 12 minutes left in the period). At KF6L18 and 6L28 students successfully bid to slow down the pace of the lesson. It would certainly be regarded by participants as anomalous for students to try to accelerate the pace of the lesson, tho teachers do occasionally treat SQs which diverge from teacher's intended line of thematic development as 'getting ahead of us,' as tho the S-Init had done so. One does not expect to hear students say 'OK, Mr. T., let's move on to something new.' One does hear 'Wait, Mr. T; do that again?' and the like. This asymmetry would seem to reflect the convention that teachers set goals for the lesson (and students do not), and teachers' goals are expected to be maximal for the time available (to do as much as possible), while students' goals (if any) and their preferred pace are expected never to exceed teacher's.

3.2 'Thematic' Tactics

The regulation of participant behavior, especially of students' behavior by teacher, is accomplished not only through the system of structural options by which classroom interaction patterns are constituted, but also by strategies whose tactics depend on the thematic content of the discourse. In Chap. 5 we will examine the very regular relations between behaviors which index students' communicative engagement with the lesson and teacher's observance or violation of a number of 'stylistic' norms of the 'classroom science' register, but students' attentiveness to teacher increases not only when what teacher is saying becomes stylistically unusual but also when teacher's discourse 'content' is 'marked' in other ways. Because register norms include restrictions on thematic content, there need be so sharp separation between these two kinds of marked discourse. Where these discourse features (to be analyzed in Chap. 4) seem to be frequently used in the service of interactional control, they will also be discussed in this section. Thus the strategy of 'building a mystery' is a stylistically marked feature in relation to the register norms, while the message 'this is important' marks the associated theme, but does so through the conventions of the 'unmarked' style. Both are associated with increased student attentiveness to teacher and reduced norm-isolating behavior. One should also note that when we deal with meta discourse, in which the discourse takes itself as theme, thematic tactics and structural moves may coincide in function, it is still wise to analyze such acts both interactionally and thematically because while these aspects of meaning may be equivalent 'here,' they may form parts of quite distinct larger-scale patterns in the discourse.

'Not an Answer; Not the Question'

Consider first a tactic which uses a metadiscourse move structurally, controlling interaction, and thematically, to control what students may say. At 2L27-8, JR says "You're not answering the question.' From lines 2L4-18 it is clear that there has been a lot of siding and other norm-violations just preceding. JR has a high tolerance for this (e.g., he ignores one student's accusation of another at 2L4-6), but admonishes a student for talking at 2L13. Finally after repeated student complaints (2L17), teacher signals a boundary and shifts from a loose Triad Dialog pattern into TMonolog (2L18-22). Interactionally he is 'reining in' the discussion, monopolizing the floor; thematically he is trying to channel discussion, to declare divergent themes introduced by students as irrelevant. The next student answer (2L23-5) diverges again thematically and it is still hard to hear student over the siding. Now teacher, in a strong insistent voice, declares that student 'is not answering the question.' He initiates dialog by reformulating the previous TQ to avoid student's new divergent theme. When the response is still unsatisfactory, teacher first formulates a TQ to constrain the thematic development again, but then adds some metadiscourse (2L30-3L1) to bid, quite indirectly, that students try to follow his thematic lead (cf. SC3L19, use of 'I'). Throughout this period teacher is trying to exercise interactional and thematic control. The particular tactic of interest (2L2708) comes where we expect a TEval move, and carries the force of TNeg Eval, but its content carries (at least) two other kinds of meaning: first that student's answer was thematically divergent ('getting away from the question/topic'), but also, by thematizing the question and answer routine itself, it indirectly reminds the class, especially in the strong, insistent tone in which it is said, that they are not playing the game, that they are here to answer his questions, and by implication not to be 'talking,' etc. In fact, over the period from 2L18 to 3L10 student attentiveness does markedly increase, even though there are no admonitions. Teacher is asserting his control of the discourse; a reminder of his right to judge when a student is or is not 'answering the question' (and not just the acceptability of an answer) bridges between the thematic and interactional control aspects of teacher's presumptively privileged role. Note also that this function of 2L2708 operates as part of a layer pattern: teacher moves at 2L18, 27,30 all indicate by their metadiscourse content that what teacher is saying will 'straighten them out' i.e., identify for studentshow to construct acceptable answers. Students tend to pay increased attention to discourse which is thus marked as 'helpful' or 'orientating.' In KF (2L17-20) we find teacher indicating that student has not answered the real question. The situation is complex. This student ('Smiley') is publicly explaining his boardwork. Another student asks a question (2L7-8), whose status becomes ambiguous because teacher misinterprets her. Because of the 'guerilla talking' he asks her to repeat; her repetition is confused and teacher misunderstands it. Then 'Smiley' proceeds on the theme of her original question, but in his own temporary confusion over one aspect (gain vs loss of elections) he does not explain what she wanted to know (how many elections). Teacher now identifies this latter aspect as 'the question,' using his characteristic 'very quiet voice' to emphasize it and indirectly judging that student's explanation, while correct, did not answer 'the question.' Simultaneously teacher's tactic exerts thematic control and reinforces interactional control against the background of the 'guerilla talking' as in JR (above). We note that KF's TPosEval move is embedded in his 'not the question' rejection of student's explanation, accomplishing its belittlement of a correct statement by marking it as something 'we know' already and not really important, not to 'the question.' In Sec 3.4 we will analyze in detail a case where EL (10L10-12, 19-21, 22) exercises interactive control, using metadiscourse TEval moves as admonitions, by thematizing his role as evaluator of student answers (and the power relations implicit in this), rather than using the more usual TEval locations.

In the preceding examples we have already seen several aspects of the more direct ways in which discourse whose primary function is the development of the science themes of the lesson also serves to regulate behavior. Teachers may try to control student behavior, especially to increase their attentiveness, by marking a point as especially important, or as new material; conversely, they may reject student initiatives, responses, or dialogues by marking their content as unimportant or 'old,' or by introducing 'authoritative' new principles on their side; they may increase the difficulty of the content, or provide summaries and explanations at times when they need to focus their students' attention more narrowly on themselves (cf. use of writing at the board, sec. 3.1). Teachers may create a 'mystery' about the topic and use this as a tactic of control, or they may thematize, usually humorously or indirectly, something that bears on the personalities or competence of their students (e.g., combining a control tactic with indirect admonitions as in LG6L26).

'Marking Importance'

Admonitions are fairly rare in DRS; he is tolerant of quiet siding and his students assert their independence more through critical or joking comments than refusal to engage with the lesson, but in line 17L30 he interrupts his answer to an SQ to sharply admonish the whole class for its inattentiveness. In fact they are mainly siding on the topic just discussed ('electron dot notation'), which has puzzled them, and been labeled as difficult by teacher (cf. 16L17-17), but they are not listening to him. Teacher reinforces this admonitory control move by marking what he is saying explicitly as something that 'it'll be important to know,' and linking it to a theme ('bonding') which has presumably been marked as itself important. Both interactional control and thematic development functions are served by this move. When KF moves to turn over principal speaking-rights to a student who will dictate notes for the class (5L28), the lesson is in a brief period and students are increasing their siding. Teacher's move creates a quasi-Seatwork sittype, whose behavioral norms in practice may tolerate such siding. After a few seconds pause, teacher addresses whoever will dictate the notes, marking the event and what will be said as especially important: 'Speak it clearly...your words of wisdom' (5L30-6L1). One student responds, facetiously, '*Oh*-oh' as if to mark the danger of a false step at so critical a point. But the class as a whole becomes quieter and more attentive to teacher, and then to his nominee. LG (11L7-10)also marks information as important at a point where he has just been challenged (see detailed analysis in sec. 3.4 below).

'Marking New/Old'

It is also a regular practice of teachers' thematic development (see Chap. 3) to mark information as New/Old, as well as

Important. This practice may also function as a control tactic, not only to increase attentiveness by labeling information as New, but as we find in LG (11L7-10), and at LG (6L14-16, 2L24-6), by labeling information as Old, teacher creates a presumption that students are expected to already know it, thus increasing the pressure on them to answer correctly (which requires attentiveness) since failure on such topics reflects more strongly on a student's competence than an ordinary failure. Thus LG says 'I expect you to remember,' 'you should have learned,' and 'if you didn't know this before.' Similarly, EL (10L14-15) admonishes a student in this way, saying 'if you didn't listen to what we did before' in a situation where he is trying to impress on students their responsibility to pay attention.

'Regulating Difficulty'

In this same effort, LG has also used a 'trick question'; i.e., a question whose acceptable answer is masked by apparently easy and obvious, but in fact unacceptable answers (see sec. 4). Teachers may use more difficult questions as a tactic to compel closer attention or demonstrate student 'failings.' DRS, carrying on from his structural ploy to hold students to the 'bids-nomination' turn assignment procedure (see previous section), poses the most difficult question of this review episode (at 2L5-8), one which no student is likely to be able to answer quickly and with enough confidence to venture 'calling out' and violating that procedure. In fact, no one does, and even a relatively 'bright' student answers unacceptably after he has bid and been duly nominated by teacher.

'Introducing Principles'

Just as teachers may introduce difficult Qs, such as DRS's above, which called for a synthesis of all the concepts used in the review, or may move themselves into a summary or explanation which tends to draw students attention, so they may combine these and other common tactics by introducing new, important, difficult 'principles' in monolog explanations. This tactic seems to be reserved for situations in which teacher's control is threatened thematically as well as interactively by S-Inits, especially SChalls. This tactic often invokes an authority beyond that of the teacher. The authority of a 'law of nature' is remarkably effective in its regular use to terminate and insure teacher 'wins' T-S Debates. Not only thematic control, however, is involved; in the T-S Debate, student initiatives may dominate the interaction structure as well, with students assuming speaking-rights and contradicting teacher, and with teacher very much on the defensive. During and after teacher's use of this tactic, however, students tend to listen intently and not renew their assault. Because of the interest of the complex dynamics of such incidents, we will describe three of them in detail in sec. 4.

'Mysteries'

Creating a sense of 'mystery' in a lesson is a tactic teachers would describe as 'motivational,' i.e., as an effort to provoke increased student interest, to arouse curiosity. Teachers do this either by indicating that some fact or phenomenon runs counter to an obvious or commonsense interpretation, implying some deeper mystery to be solved, or by hinting to the class that they are concealing some important secret which will be revealed. We find this first pattern in KF (10:38 seq.) where a new topic is introduced in the guise of an apparently impossible task of great importance: 'if only there were a way to...' 'Is it possible to...?' Teacher signals boundary just before this (completing Going Over the Do Now), but makes a strong thematic continuity with what preceded. Student attentiveness increases sharply. The 'new topic' marker comes only at the end of teacher's monolog; it is the element of importance (here it's practical relevance) and the tactic of mystery which distinguishes the talk that draws student attention. In LG the second pattern serves teacher as a continuing thread by which he 'strings along' the class, promoting anticipation of the 'very, very special name' at 7L12-15, 19-21; 8L29-30; 12L9-10. The period ends before the 'special name' is revealed, but the device was effective enough that it prompted my non-science trained co-observer to ask me what it was (as several students asked each other and teacher), and I examined the tape, having been preoccupied with non-content aspects of the lesson in my own note-taking, to readily discover that teacher had in fact already presented the mysterious name, preparing for a closing 'revelation' of it (probably with efforts to get students to see it for themselves) that would have neatly 'bracketed' the entire Main Lesson.

'Being Funny' and 'Getting Personal'

It is a commonplace of our culture that humor is a principal 'lubricant' of social interactions. Participants in these lessons laugh, as we all do, at incongruities, whether seemingly 'intended' or not, and thus mark for our analysis both what seems incongruous to them and those events of classroom discourse where potential friction seems to require some lubrication to smooth them over. Processes of behavioral control create such friction and we are not surprised to find humor often associated with admonitions. Laughter often accompanies incongruities of style, violations of the science discourse norms that favor a 'serious' and 'formal' style (see Chap. 4). Both of these criteria for expecting humor are met when teacher (or students) discourse 'gets personal,' i.e., thematizes or indirectly comments on teacher or student personal competence. Most usually we encounter highly implicit or covert suggestions of incompetence couched in ironic, sarcastic, or 'joking' terms, creating a metadiscourse context of situation in which offense taken may be met with the feigned innocence of 'I was only joking.' In fact the ploy usually works well enough that no overt challenges occur. Teachers reflect humorously on their own, or the school's shortcomings, and more pointedly mask with humor their efforts to control students. Students use irony as a cover for their criticisms of teacher and the preferred mode for enforcing register norms on teacher &see Chap. 4). Teachers themselves use overtly humorous overtones to mark their departures from norms as 'intentional' rather than accidental.

We have already encountered many examples of humor in admonitions. DRS asks a student who spoke when another had been nominated if his name were 'Janice.' JR embarasses a student who is turned round to his friend, who feigns innocence, saying to the latter 'He likes you.' RF admonishes the class for 'guerilla' talking. LG uses humor frequently in this way, e.g., telling a student to take off his 'great hat' and 'just look wonderful,' or admonishing a Chorus answer 'This isn't the Greek drama.' In Chap. 4 we will identify many stylistic norms whose violation provokes laughter, or which are marked by humor when spoken. So we learn that words and not gestures make for proper scientific description (DRS5L16-6L17), and words like 'fat' and 'skinny' are anomalous (DRS7L1-5), as are descriptions of rope as 'pickled' (RF), or far-fetched analogies that lead to mention of 'hot dog vendors' (by JR), 'CIA agents' (by KF), 'the Planet of the Lost Chicken' (LG), or 'how Einstein made his fortune' (DRS).

Humor is usual when teachers allude to their own shortcomings. LG makes a joke of his clumsiness, blaming his 'old age' (6L22-3); BB of his poor drawing (7L22-3) and KF of the failure of his demo to work properly (10:49). DRS jokes about the school's lack of equipment (7L9-12). Apart from admonitions, teachers also use humor when alluding to student's competence, as LG does in joking about how interested students are in the subject (3L4, 12L5-8) and as EL does in his long humorous parable that introduces his Lecture on students' poor performance (1:06-1:12). Students make joking or ironic criticisms of DRS' use of anthropomorphic language (e.g., 13L30) and even of his pronunciation of 'Iodine,' which becomes a running class joke on both sides (15L22-5, 17L8-11, 20L23-5).

EL jokes about giving out the pass 'on Christmas and Easter' as a direct tactical use of humor to control a student's behavior in a situation where he had already 'gotten personal,' using humorous exaggeration to excuse the student of bad faith in her request and thematizing the extent of her need to use the toilet (6L13). Here, as in most of the instances where participants act to regulate one another's behavior or elude regulating norms, humor and the rapid flow of events disguise (in the absence of time for reflection or the microanalyses we make) powerful interactional tactics that would otherwise be perceived as aggressively hostile (e.g., teachers' exploitation of students' vulnerability to comments on their personal habits and appearance or their sexuality). Participants do not perceive the events in this way, but an outside analysis must certainly construct connections between such tactics of control and the underlying inequalities of power at work in classroom discourse. Here as elsewhere microanalysis yields a not very 'pretty' picture of the classroom, which participants themselves would 'resist,' much as people resist the accounts similar psychoanalytic techniques produce of everyday events. In a culture which promotes ideals of human equality and independence and at the same time regards as normal and necessary what are essentially oppressive (for teacher and students, parents and children, bosses and bossed) modes of socialization, only the pervasive disjunctions of ideology can abet their relatively stable co-existence. (See also Chap. 4.)

3.3 Students' Tactics

The strategies by which students participate in the processes of mutual regulation of behavior in the classroom have usually been noted along with those of teachers, since many are common to both. Certain tactics are especially commonly used by students, and these are noted here.

Within the patterns of Triad Dialogue, student moves other than conventional SAs may shift interactional control at least partly in favor of students. Calling-out and Chorus answers tend to pre-empt teacher's right to nominate who will answer. Declining and delaying tactics of nominated students may evade the expectation of SA and TEval, at least for that student. A special tactic, quite often used, and rarely if ever admonished, is student use of questioning in tonation when giving an answer. Teachers usually ignore this feature, responding as if the SH were a statement (e.g., DRS 1L20, 2L10), but this tactic is quite revealing for our analysis. The presumption of Triad Dialogue is that even though teachers know in advance the answers they expect to their questions, and students assume they know, students normally answer as if teacher's questions were genuine requests for information. When students answer with questioning intonation, not only do they express uncertainty over their answer, and thus buffer themselves against a possible negative evaluation by teacher, but they turn the tables on teacher, breaking the illusion on which Triad Dialog rests, in implying that teacher does know the answer, or at least that teacher is the judge of answers' acceptability.

We have already noted that students may enforce on teacher a previously announced agenda, often that of an external text, as in DRS (5L2, 8L8) and KF (3L19). Students also act to enforce stylistic norms of classroom science discourse (see Chap. 3), and when they do so they usually in effect call into question teacher's competence as a teacher, though indirectly, creating a tension often moderated by humor (cf. DRS 7L1-5, JR 5L18-19, LG 6L13).

Student requests and challenges, the former in a direct and obvious way, the latter in a more complex fashion described in some of the S-T Debates analyzed in the next section, are tactics by which students assert their interests in the interaction. Of the many functional moves by students that may be realized with the surface form of a question, creating the expectation of a response by teacher, and contrasting with SComms which students know teachers often ignore, those which belong to the regulatory meta-discourse are especially interesting. Thus in EL we find (1L16) a student saying 'Are you asking which one of those four?' at a point in the discourse when several students have failed to satisfy teacher. The student's question indicates that part of the difficulty in answering has been for students to ascertain the kind of answer teacher wants, the thematic subsystem in which to search for a satisfactory answer. EL confirms student's 'search hypothesis' and student then immediately gives an accepted answer. Similarly in DRS when students are confused as to the definition of the sittype, SQs lead teacher to make clear what he is doing (10L24-7). A related tactic which may function as a request for clarification, or as a bid to override a normally incumbent student behavior, is to ask explicitly whether that behavior is expected, as in asking 'Do we have to copy this?' In EL (2L27), teacher treats it as a bid to override; in LG (9L17-19) teacher treats it as an ordinary request for clarification.

Given their relatively restricted speaking-rights in classroom discourse, it is not surprising that students exert much of their effective control over teacher and the lesson interaction through non-verbal moves. We have already noted, for example that students in effect bid to end the lesson by putting down their pens, closing notebooks, putting on jackets, etc. They may indicate their boredom with a teacher monolog, or their impatience with a student-teacher dialog by increased siding, decreased gaze to teacher, non-lesson activities, etc. Even students' probably unconscious shifts of posture serves as effectively as the verbal boundary signals by teacher to mark the episode segmentation of the lesson. We will discuss such non-verbal dynamics of students' communicative engagement in the lesson in Chapter 5.

4.0 Interactional Strategies in Operation: Analyses of Episodes

4.1 Negotiation of Interactional Control

Two instances of the negotiated character of interactional control in which the status of moves is subject to retroactive negotiation between teacher and student are found in DRS. In the exchange in lines (2L2-5), teacher first asks an elliptical, 'fill-the-blank' question parallel to that in the previous exchange (1L24-3L1). Janice's first response, identical to the ultimately accepted answer, is said fairly softly, perhaps not quite in full 'public voice,' and comes immediately at teacher's pause, as if completing his utterance. Teacher now voices his pause, and Janice repeats her answer in asserting public voice. These act retroactively to define teacher's 'Uh' as equivalent to 'What?' a request for repeat of an SA. But teacher now says 'Janice,' a nomination of Janice to answer _after_ she has already done so. This is turn has the effect of redefining the status of that answer as only a bid to answer, and that of his voiced pause as only a pause awaiting bids. Janice now answers yet again, less loudly than before, and teacher overlaps her speech by himself saying her answer, his usual form of TPosEval. Yet these features in effect acknowledge that her last repeat of the answer was merely pro forma, that he and the class had already heard at least her first repeat. Teacher is working here to establish bids and nominations as required, despite their omission in a previous exchange (1L22-4); he puts interactional control ahead of thematic development ('getting the answer'), while Janice's strategy had just the opposite emphasis.

Immediately following (2L5-16) is a complex exchange where teacher sacrifices interactional control to the thematic objective. Teacher asks a long, apparently difficult question that brings together several thematic lines, then he brackets out his comment on an interruption by resuming the regular structural sequence of moves of Triad Dialog with a Norm of Ron, a student who usually answers acceptably. But Ron's answer, hedged by questioning intonation, is not what teacher wants. Teacher reacts by commenting on Ron's answer. The absence of explicit positive evaluation normally implies that an SA is defective. One such indirect negative evaluation is a T-Inform move that 'exposes' the answer's defects (cf. reductio ad absurdum), actually creates them, by developing consequences of the SA in a context chosen by teacher for this purpose. (Teacher's thematic strategies for controlling what counts as 'correct' will be discussed in the next chapter.) Teacher is now interrupted in the midst of a clearly uncompleted sequence ('one here...one here...') by a student calling out 'Carbon,' the answer he wants. This utterance, however, is not appropriate to the interactional structure teacher is establishing, though it is appropriate in an alternative construal of the states of the dialog, in which, if teacher negatively evaluates an SA, the floor is re-opened to other answers or bids. Teacher briefly continues his sequence, then re-orients to the new situation created by the student and asks 'Who said it?' He might have followed this effort to regain interactive control by repeating the tactic he used with Janice, but other students now call out 'Carbon,' further defining the situation as 'floor open' and at last teacher himself says 'Carbon,' interpretable as a TPosEval of someone's SA and a retroactive ratification of the student's version of the status of the interaction. Teacher immediately moves to clinch the thematic development and does not press for interactive control (as he could have by saying, e.g., 'Hold it. One at a time.'), which had clearly passed to students here.

4.2 Strategies and Interactional Control

While teacher's evaluations of SAs principally serve to define and control the thematic systems of classroom discourse, the following excerpts show teacher's use of Evaluation options in interactional control.

In EL (8L11-20), we find teacher posing a question for the second time. Comparing it with the first version (8LZ), we see its increased force as a Call for Bids, appropriate because of the long pause before getting a single bid for the first version. The question form also impugns, or at least challenges students' competence, TNorms Victor, who had not bid, and prompts him to answer. After 3 seconds, teacher provides Victor with a 'clue' in the form of a subsidiary metadiscourse question, asking him to name the current theme ('What've we been _talking_ about?), and implying that the name of the theme will at least partly answer the main question. Teacher has _not_, however, identified the level of the thematic structural hierarchy whose theme he wants named, Victor answers, in questioning intonation (thus putting some of the burden of his uncertainty back onto teacher), at the lowest level: the theme of the most recent thematic episode ('water waves?'). Another student now answers with the theme of the longest thematic episode so far in the lesson ('the spring' TR2-5), which Victor seems to accept. Teacher's evaluation move is 'What else?' implying both that the second SA is acceptable, and that there is another answer that he really wants, thus reinstating the main question and again calling for bids. Teacher now repeats his 'clue' tactic, and his choice points to a _higher_ level of the thematic hierarchy. Students' answers jump to a higher level, mixing a more general and a more specific theme ('wave motion' 'sound'). Teacher now gives a positive evaluation ('Yeah.') which is incomplete until he identifies which answer is right, and he does so in a move which asks 'who said sound first?' Teacher's evaluative strategy separates for us the usually conflated moves of evaluation of an answer (thematic) and evaluation of a student (interactional). It does the additional interactional work of renewing a pacing norm (credit goes to student who answers first), and engaging student in true dialog. Teacher's 'y'did?' adds a personal dimension to this exchange, almost as in a private aside; then teacher gives the public TPosEval of the student, and he then marks the answer as important by repeating it, elaborating it, and writing it on the board.

Soon after (10L8-28) we again find a main TQ (10L8) to which answers unacceptable to teacher are given, clues provided, and finally an acceptable answer obtained. The first response is by Ethel (10L11), who then interrupts teacher's reaction (which, not being positive, is assumed negative) by reversing her answer. One needs to understand here that Ethel believes that one of two possible answers must be correct: either the air moves to the left or to the right. Teacher's evaluative move continues, in regard now to either answer, first the indirect, and then a direct negative evaluation ('No good'). Ethel is about to protest (one must be right), but a fellow student tells her she is wrong either way. Teacher now combines further indirect negative evaluation with an admonition for not having paid attention. The interactional control function of the admonition is dependent on the (thematic) evaluation. Again an evaluation of the student is built onto the evaluation of an answer. Teacher now poses a subsidiary question, the expected answer to which is thematically equivalent to that expected for the main question. He ignores one called-out answer (10L17), in effect negatively evaluates it, by repeating the question (prompting students' memories of a demonstration), and immediately directs to Fred a 'trick' question, one which renews the presumption that one of 'right' or 'left' must be correct. Fred answers 'to the right' and teacher evaluates with 'I'm gonna call it wrong' using an unusual location (repeated at 10L22) which reveals teacher's evaluative options. He could 'call it' right, because the expected answer is that the motion is both right and left. As with Ethel, teacher begins now to prepare a negative evaluation of student as well as of his answer, by indicating that the answer is on the board (hence should be known by Fred). Fred looks at the board then, like Ethel, falls into teacher's trap by simply reversing his answer. Teacher negatively evaluates in the same terms again and now indirectly admonishes Fred for not taking notes, not being prepared for class, and by implication, not paying attention. The interactive moves here are again built on the thematic evaluative ones. Finally teacher calls on a student who bid and gets the acceptable answer 'both ways,' which he evaluates with an almost offhand 'Yah, of course,' thereby not only giving TPosEval of this answer, but further putting down the students who could not answer acceptably by emphasizing the obviousness of the answer. Underlying teacher's control here is the presumption that, although students did not understand a point, teacher may still label that point as 'obvious,' 'old material,' 'something you should have learned,' and thus if students fail it is their own fault (cf. EL3L1-3).

A rather different strategy is illustrated in LG (1L11-2L1 cf. LG 9L27-10L17). Teacher poses his question, pauses, accepts Gary's bid, Gary answers, then at teacher's requests, repeats more loudly. Teacher's response is 'O.K. Anybody else?' He uses a special non-falling intonation for the 'O.K.,' which contrasts with the falling intonation when 'O.K.' acts as a true TPosEval (e.g., 2L20), and with the falling intonation and emphasis of the 'O.K.' in line 1L23. Teacher gets another answer and reacts with this same non-falling 'O.K.' and yet a third nomination. Following the third SA we get the emphatic falling 'O.K.' and a weak positive evaluation that retroactively includes all three answers. Comparison with a similar sequence (9L27-10L17) reveals what teacher is up to: the first two 'O.K.s' are non-committal, they signal that teacher wants to hear other SAs before closing the exchange on that question, without implying that an SA was unacceptable. The emphatic 'O.K.' closes the exchange (cf. the emphatic 'Exactly' at 10L17, which also indicates that teacher prefers the last answer for thematic purposes). The use of this strategy enables teacher to enlist the participation of more students on a given

TQ without all but the last having to be negatively evaluated. It also permits teacher to select from all the SAs just those features important for his planned thematic development (e.g., 2L30-3L3; 10L13-17).

4.3 Competition for Discourse Control

At the start of the Main Lesson in JR, teacher and students compete for control of the discourse to a degree that is rare in the corpus as a whole. Teacher begins with proxemic and verbal boundary signals, bidding the start of the Main Lesson, and quickly gets the direct attention of about 80% of the students. He begins a Narrative monolog about a science fiction movie, and almost immediately (1L3) a student calls out, overlapping teacher's speech, with a continuation of his utterance, but in a different thematic system (a movie on a different theme with the same named actor), and other students comment on teacher's stylistic norm-violation. Teacher continues and at 1L8, another student (Mr. Y) jokes that the Blob must be Scott, his mock-adversary in this lesson. Teacher continues and at 1L12 a student jokes at teacher's narrative again. The class is negotiating how seriously teacher's narrative is to be taken. Just as he finishes the story and is about to make some point about it, he is actually interrupted by an SQ that introduces a lesson theme, anticipating teacher, and in effect bidding the start of serious 'scientific' discourse. Teacher responds to the SQ, but does not assert either interactive or thematic control. Now Mr. Y breaks in with a joking characterization, a reductio ad absurdum of teacher's thematic strategy, while another student actually contradicts teacher's answer on its own terms. Then as teacher begins to formulate an issue, Mr. Y loudly criticizes his stylistic deviance (see Chap. 4). T yields the speaking turn to him, then emphatically resumes, regaining the floor, and poses a question. He does not pause for bids, but begins to restate this question. A student calls out an answer before he can finish and then just as he finishes Mr. Y answers opposite: ('Sure why not?'). Teacher responds to the first answer with a follow-up question which is in fact Mr. Y's query 'Why not?' Only at this point, in selecting a nominee and legitimizing the first called-out answer and not Mr. Y's (though his is in effect thematically legitimized), does teacher begin to assert structural control of the interaction. There have been no admonitions thus far, even indirect ones, no Triad Dialog until now, or regulatory metadiscourse (except the weak 'the question is,' which is lost behind Mr. Y's norm enforcement). Students have taken the initiative frequently, have nearly succeeded in defining teacher's narrative as silly and unscientific hence irrelevant, and have introduced the principal thematic system (one-celled animals). Teacher acquiesced in all this. Now teacher's nominee answers, and teacher begins a negative evaluation (2L5), but is overlapped by one student accusing another of a behavioral violation, in effect inviting teacher to admonish. The nominee now acts to forestall the negative evaluation by elaborating his answer, and Mr. Y poses a question about that answer (2L9). Teacher only asks student to repeat, in effect legitimizing Mr. Y's question. Now another student complains he can't hear the nominee, and (finally?) teacher admonishes this student, whose complaint is out of order as well as transparently insincere. The nominee reports, there is considerable siding, and now complaints are renewed, again pushing teacher to take more effective control. This he does at 2L18 by using a boundary marker to signal the end of the previous sittype (construed by students as free-for-all discussion), metadiscourse to define the task, and within that to focus the thematic issue, reverting to his original question (minus the stylistic exaggerations of the film context) and ruling out a sub-theme ('paramecium') introduced by students (2L9-10, 14-15). He establishes the triad pattern: following the TQs of 2L20-22, there is one student answering (2L23-5), and then a very strong control move, indicating that teacher intends to keep the dialog in a narrow thematic course now (no 'free forall'): 'You're not answering the question.' Then comes a follow-up question. Triad Dialog continues now, though teacher still permits students considerable thematic latitude, and students clearly follow teacher's lead both interactively and thematically.

In this segment of their discourse the apparently strong competition for control seems to arise in part from teacher's minimal use of control strategies, in effect offering to share control more fully with students than is usual in these lessons, or at least refraining from adopting even the 'benign' authoritarian posture of control-by-right one more often hears in the classroom. It is interesting that in this 'power vacuum' student moves are more frequent, less often simply responsive, and more often initiatory. While teacher ignores many of the moves, as the segment develops these moves seem to push teacher to take control and criticize him for his deviations from more customary classroom patterns, both thematic-stylistic and interactional-regulatory. It is quite possible to see such student behavior, and much of student control strategies, as very conservative, creating situational pressure on teacher to conform to the teacher role to which students are accustomed (though clearly students also attempt to serve their own narrower interests, as in clarification requests or bids to end the lesson).

4.4 Analysis of T-S Debates

In this section we will examine T-S debates in three lessons with different teachers (JR, LG, SC). In all of these the common strategies of this sittype are illustrated. Our first episode for analysis begins at JR (7L13). The class has been discussing possible limits to cell size, and at 7L5 teacher has signaled a boundary for the end of this discussion and begun a TSummary monolog, renewing points made in relation to an analogy of the cell to a large crowd. As he does so, a student calls out another parallel factor and teacher integrates this into the summary. He then connects the crowd analogy back to the original context (the cell) at which a student interjects a conclusion about cells, but teacher ignores this and begins to systematically restate the points in the cell context. After the first, concerning food, Mr. Y interrupts teacher with an SChall (7L13-14), which initiates the debate. Y's statement, in the thematic context, constitutes a challenge because it contradicts the implicit assumption behind what teacher has just said. It creates a logical argument (if...,then...) and links this to teacher's own assertions (so,...). Teacher immediately responds, defensively, with the characteristic 'concessive-adversative' tactic we will see again and again in these debates: 'It's true that..., but...' In this case the counter argument is actually supplied by another student who completes teacher's utterance when teacher pauses to formulate it, teacher affirms the completion ('Right.'), then states the complete argument. It is interesting that both teacher and students use the syntax of logical relations much more frequently in these 'adversary' discussions than they do in other dialog (or teacher monolog) sittypes.

So far we have only an SChall and a TResponse, but this is truly the beginning of a debate, for another student now takes up the role of challenger (7L22-3), acting in part as spokesman for one group of siding students who are commenting among themselves on the debate issue (there are several of these groups until about 8L20). This student also begins with 'But...' to signal an objection to teacher's argument. Teacher encourages this student to speak and ratifies his role as spokesman. That designation is challenged by Mr. Y (8L1), leader of another group, when teacher's request for repeat permits interpretation not just as 'I couldn't hear you' but as 'Can you make the point so I can understand it?' Mr. Y requests the floor, thus acknowledging teacher's right to control speaking-turns, for unlike other instances where Mr. Y is hardly shy about taking the floor from teacher, here he needs teacher if he is to take it from designated student. But that student continues, and is supplemented by another member of his side-group (8L5). Teacher's response this time is not in the concessive-adversative mode. He introduces new, privileged information 'Well it turns out that...' and asks 'O.K.?' as in the 'check-up' move of a response to an SQ rather than to an SChall, treating the student's objection as in effect calling for additional information, which--his response concludes--invalidates their point. This strategy is close to one of the two common ways in which teachers terminate debates, by invoking the authority of facts or principles not known to students, which they assert settle the issue in their own favor. (See below.) But in this case the new information is relevant only to the side theme of the second objection, not to the main objection.

Immediately at the end of teacher's response, SM (another persistent challenger of teacher) starts to raise yet another objection (8L10) 'Yeah but...' himself appropriating the concessive-adversative (C/A) strategy. But Mr. Y cuts him off (SM had not been designated by teacher) and clearly states the min objection, using 'if...then...' structures. Teacher responds with the C/A strategy, but now makes a major use of the tactic of invoking authoritative principles, in this case the 'geometry' principle of relative scaling of volumes and surface areas, 'that turns up here' (cf. 8L6 'it turns out that'). Teacher marks this information as belonging to a realm outside science, and which students are therefore not expected to know (cf. LG's use of this tactic, below, where the reverse occurs). Teacher uses logical relations structures, with a general conclusion, applying the principle to the case in hand 'So that, even though...' But his use of the principle does not settle the objections, though such appeals to authoritative principles usually do end the debate (cf. LG and SC below), but not here. Led by SM (who is apparently always ready with another objection, see below), three students now pose a different form of the main objection. The third student is himself interrupted by Robert.

Robert's initiative is outside the debate structure. He asks teacher teacher's own original main question (1L23-2L1; 2L20-22). This acts as a bid to end the debate and get 'the answer.' Robert has 'called the question' in parliamentary

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terms. Teacher, ingenuously or not, responds non-commitally to this move? 'That's what we're trying to figure out.' SM now bids to continue the debate 'Yeah but Mr. Torro.' He uses the debate 'formula' 'Yeah, but...' and teacher's name to signal a formal bid. A bid to continue debate is in order here because it is not clear whether teacher has accepted Robert's move to end debate or not. Teacher recognizes SM. Three exchanges with SM follow, constituting a dialog, during which other students, especially Mr. Y's group grow increasingly impatient, coughing loudly and pounding on their desks, creating pressure to end the dialog. The observer gets the impression that SM prolongs the dialog more for the pleasure of interaction than to settle a thematic point. His final argument (9L24-5) introduces a theme only very distantly linked to the main objection (cf. 8L10). Teacher begins to reply 'But it--' then breaks off and unilaterally terminates the dialog: 'Well let's not get into...' This seems to be the only way to stop SM (cf. 11L21-2). Teacher now signals a boundary and begins a TExplan monolog, introducing it, ironically, as an answer to Robert's question. This debate is over, and teacher has interactive and thematic control from 9L28-10L24 (actually a full minute and a half), during which teacher monologue is combined with a Copying Notes sittype, and teacher successfully postpones a new bid by Mr. Y to resume dialog.

A briefer, but structurally similar debate occurs in LG (5L20-6L22). Teacher has just summarized a discussion of how sunlight heats the ground, and written this on the board for students to copy. As he finishes writing he makes a single synthetic statement that relates the various thematic strands (5L17). As he does so, Erin begins to side. Teacher notes this and asks, "Erin, you have a question?' a tactic which functions as an admonition if Erin is off-subject, an invitation to public rather than private dialog otherwise. Erin's question is in fact a challenge, repeating teacher's synthetic assertion and opposing to it a seeming contradiction. Teacher replies with C/A tactics 'Well [it] is...But...' (5L23-6). Erin responds by denying the distinction teacher has used; teacher offers an example that contradicts her general denial (5L26-9). Another student now suggests Erin by appeal to teacher's own example, and Erin elaborates this point (5L30-6L3). Teacher tries to interrupt her by overlapping her speech (6L2), but teacher pauses, she finishes, and then teacher simply reasserts what he's already said at (5L25-6). Erin takes the offensive again, using several logical relation structures (where teacher has used none overtly so far), and preventing teacher from taking a turn before she has finished by resuming with a logical conjunction 'Because...' (6L7-8). Teacher responds not logical or argumentation, but by simple assertion, and states an apparent tautology (6L11-12). Now Erin challenges teacher's competence by a mocking transposal of the tautology, and other students laugh at this, in effect supporting the enforcement on teacher of a discourse norm that forbids such tautologies as empty of content and requires cogent-sounding logic in response to logically phrased SChalls.

The overtone of personal criticism is now returned by teacher in a challenge of student competence (6L14-15): 'if you remember...you should've learned...' This is a return of the debate's use of personal pronouns to mark personal themes. Teacher invokes a 'rule,' and by using 'should've' and marking this information as 'old news' puts students on the defensive not only in relation to the rule, but to teacher's authority to label them 'good' or 'bad' students by judging what they should or should not already have learned (cf. EL 10L8-28). From this position of strength, teacher releases students from the onus of not having learned what they 'should've': 'if you didn't it's O.K.'--and announces he will teach it, in affect use it to win the debate. But Erin forstalls this effort to create a TExplan monolog sittype, by asking as an SQ that teacher answer with this rule, bidding maintenance of the dialog sittype, and challenging teacher's power-play. Teacher does not quite let Erin finish, overlapping the very end of her utterance, so that he need not be heard as replying to it, and the monolog sittype is sustained. He states the principle, makes a concessive side remark (glancing toward the observer, whom he knows to be an expert on the issue), then asserts what he needs from the principle, asserts it 'actually happens,' and re-asserts now as an instance of the rule, his originally challenged statement. This is its third assertion (6L21). He tacks on one extra clause this time, foreshadowing something new and important ('something very interesting') and, consistent with an episode-terminating monolog, takes the chalk and begins to write at the board. Students copy; the debate has been ended. As at the end of the debate in JR above, during the dialog part of the exchange up to 6L14, steadily fewer students were engaged with what teacher was saying (down to about 40%), again creating pressure for teacher to assert control. An instance in which LG cuts off an incipient debate directly (cf. JR 9L26-7, 11L21-2) rather than by invoking any authoritative principle, can be found at 11L2-3: 'Yeah. It may sound funny but it's right,' which still has the C/A format.

Our third example of the use of interactional strategies in T-S Debates is from SC (5L1-6L26). Teacher has just written a summary statement on the board and begun to paraphrase it for the class. At 5L1, Charley interjects with an SQ that challenges teacher's previous statement by asking 'couldn't' the opposite be true? His challenge is supported by Victor. Teacher responds in C/A form: 'It's possible..., but we believe...,' restating his assertion. Scott and Victor now test the status of teacher's assertion, that it is 'just a theory' (cf. T/S 'we believe'), i.e., how much of a concession has teacher made? Teacher now makes a strong claim: 'This is fact. This is not a theory.' Victor expresses surprise at this, and Scott formally challenges teacher: 'Wait a minute, it can't be a fact,...' Teacher has abandoned the C/A strategy and simply contradicts the implication of Scott's objection. Scott expresses his surprise and doubt. During these exchanges the rest of the class has become quite engaged, many students have their hands raised, many are siding, and several students have called out comments or objections of their own.

At 5L15 teacher raises his voice for attention, seems to signal a boundary and indicates by metadiscourse that he will give a monolog TExplan. As he thus tries to assert control, Rosie challenges him, in effect insisting that he respond directly to the main issue of the challenge (i.e., is it fact or theory), and keeping the sittype as a dialog. Teacher continues in metadiscourse and indirectly admonishes her and Scott for challenging him for the floor (5L18-19), again bidding for monologue rights ('Just listen carefully'). At 5L20 he begins to invoke an authoritative principle, then switches to Triad Dialog (another high teacher control sittype), but siding by students does not end and teacher, aside, changes one siding student's seat. Though done as unobtrusively as possible, this is still a strong reminder of teacher's positional power. He reinstates the TQ, waits for bids, nominates Erin, negatively evaluates her answer, nominates Scott, negatively evaluates his SA (though with the encouragement 'you're getting closer'), nominates Monica, and then cuts Monica off well into a long but thematically confusing answer by overlapping her speech, makes a boundary move to signal the end of triad dialog (6L13), and puts into Monica's mouth his own statement of the authoritative principle, which he develops at length in monolog, finally asserting that it proves the point in contention. He immediately signals a major boundary (6L26) and returns to the pre-debate thematic development. The debate is ended.

In all these examples we have emphasized the interactional strategies without taking time for the interdependent analysis of the thematic content development; so, inevitably, while some fascinating similarities and particular uses of strategies may be evident, the motivation or effect of using a particular strategy of a particular point will not have been fully apparent. In the next chapter, when we have presented the basis of the thematic analysis, we will be in a better position to explore this interdependence.

CHAPTER 3: THEMATIC DEVELOPMENT AND CONTROL

1.0 Framework of the Analysis

We have found it useful so far to analytically separate two facets of the context of situation in terms of which we construe the meanings of utterances and other acts, and to which such acts contribute: the interactional context and the thematic context. Participants recognize the events we are analyzing not just as Lessons, but as Science Lessons, and their actions in them as not only interactionally appropriate or not (e.g. following questions with answers, or enacting the options of regular triad dialog), but as thematically appropriate or not. Students and teachers enact thematic systems as they enact interactional structures (cf. Mathiot's distinction between 'semiotic systems' and 'activity structures' and my response in the same issue, 1982), and they employ a variety of functional strategies and tactics of thematic development. A great obstacle to thematic analysis is the system of assumptions in our culture which takes thematic processes to be 'transparent' when we need to see them as quite a bit more mysterious if we are to ask fruitful questions about them.

The usual view is that lessons have a 'content', a set of topics, ideas, or concepts which are talked 'about'. In this view words and other acts 'tell about' the content and are used by teacher to 'explain it'. Students likewise use words to 'ask about it' and to show they 'understand it' by answering correctly. The 'it' of content thus appears as an independent entity, 'referred to' or 'represented in' classroom discourse--or any kind of discourse--and so taken as given, fixed, and external to the discourse process itself. The analysis here will take a very different view: that classroom discourse does not 'talk about science' but rather 'talks science', or at least 'talks classroom science'; that it enacts systems of meaning relationships (thematic systems) that link different occasions of discourse or different texts (within lessons, between lessons, between lesson and non-lesson discourse or written texts) and by so doing establish them as thematically related. The enactment of these systems I will call thematic development, and we will be trying to describe in detail how teachers and students do this. Notice that thematic systems, not isolated themes, topics, 'concepts' etc. are primary. 'Concepts' (a deceptive term) have no meaning except through their relations to other concepts, and the system of meaning relations is iteself immanent in the human practices of discourse that enact it. But what are these practices? and how do they help constitute thematic systems?

How do teachers and students invoke a thematic system, i.e. establish it as part of the on-going thematic context of situation? How are 'topics' introduced? deferred? resumed? changed? closed? linked to others?

How are key parameters of a system of meaning relations established: its equivalences, contrasts, generality and limits?

How does thematic development mark relative importance? 'old' vs. 'new' information? appropriate usage?

How do teachers and students share, negotiate, and challenge control of thematic development? What are the roles of explicit vs. implicit construction of thematic systems? of syntactic devices? of our language's resources of textual cohesion and intertextual connection? of metaphor, analogy and other 'rhetorical' strategies?

How is thematic development carried on through and across dialog and monolog patterns of classroom interaction, described in the previous two chapters?

In the next four sections of this chapter I will try to identify and characterize many such thematic development strategies and provide the beginnings of answers to these questions, at least for science classroom discourse. In the final section we will again examine lesson episodes in which we can analyze the situated use of these strategies.

2.0 Interactional Strategies in Thematic Development

In this section we are closest to the analysis of the previous two chapters and rely on them in describing some important ways in which teachers (and also students, see sections 5 and 6 below) utilize the options available in a variety of interactional situation-types in the service of thematic development. We will consider here mainly Triad and External Text dialog patterns and monolog forms such as Explanations and

Summaries which seem to carry the main burden of thematic development when it is most strongly dominated by the teacher. Sharing, negotiation and conflict between teacher and students and the major modes of students' control of thematic development are discussed in sections 5 and 6 below. The disparity between the thematic development roles of teacher and students is much greater than that between their interaction-constituting roles. Students simply do not operate the thematic systems of classroom discourse as much as they do its interactional systems, and while most students seem to master the latter, few come to feel comfortable with the former. Students get a lot of practice and become quite adept at 'playing the classroom game' but not at using the thematic systems we call 'science'.

2.1 Dialog Strategies

In ordinary Triad Dialog, the teacher exercises control of thematic development primarily thru TQs, and not just individual TQs, but series of TQs. We have interpreted this previously as teacher's conversion of a monolog into a seeming dialog (e.g. DRS1L18-2L5). In the initial episode of DRS, the first 'science' thematic system is invoked/enacted beginning with a TPrep (1L16), then augmented by the following TQ (1L18) and its SA (1L20). In thematic analysis the functional distinctions between these moves in the interaction pattern are no longer foregrounded; thus the TPrep and the TQ here are not thematically segmented from one another according to the more linear model we used for interaction structure. Thematic development is non-linear: many 'strands' (cf. cohesion chains) are woven together, more like the polyphonic texture of a symphonic score in which many 'voices' enter, leave, and return in different relationships to one another (cf. Levi-Strauss on). So also, the SA and the TQ, at least here, make a common thematic 'statement'. But control, or thematic or thematic initiative, is exercised here by the teacher in his TPrep and TQ moves. Examining the terms introduced: TPrep (1L16) introduces 'orbital', TQ (1L18) introduces 'elements', and TPrep (1L21) 'electron'. SAs mention terms subordinate to these (special cases of them, hyponyms) in the thematic system: 'Hydrogen and helium' (specific elements, and later also 'Boron' and 'Carbon'). 'Two electrons', and '2S' and '2P' (specific orbitals). Indeed that is all that students say in this episode. More important than the terms or categories are the meaning relations among them in the thematic system. Many such are being constructed/enacted in this episode (which will be analyzed in more detail in section 6), some in quite indirect and implicit ways. TPrep (1L16) foregrounds the relations: *(Parts of diagram) represent (particular) orbitals*, then TQ adds: *(Parts of) diagram (can) represent (particular) elements*. The next TPrep and TQ (1L21-2) develops this to: *(Different elements) have (different numbers) of electrons (in particular orbitals)*. Finally (2L5-8), we get: *(Definite) configurations of (numbers) of electrons in (specific orbitals) represent (a definite) element*. This long and complex final TQ ties together all the thematic 'strands' that precede it, creating a thematic nexus. This is the thematic climax of the episode, the most difficult TQ in it for the students to answer, and the only one not answered satisfactorily.

NOTE: Material bounded by * ... * presents thematic abstractions from the discourse text; parentheses enclose lexically implicit thematic elements. All such material should be compared directly to the actual text in the transcriptions. This procedure is similar to the 'expansions' of Labov and Fanshel (1977).

Continuing this analysis, note that lack of the expected SA here interferes with the smooth transformation of underlying teacher monolog thematic development into triad dialog.

At DRS (14L28) we can observe the teacher in the process of recasting a T-Inform monolog move into triad dialog form, clearly retaining control of thematic development by use of TPrep and TQ moves. He began as if to say 'that's why there're (14, because there are 7 f-orbitals)' but then speaks as if to ask 'and how many (of them are/should there be)?' Actually he inserts T-Inform and TPrep moves here to prepare for the desired student answer, and then continues with TQs that establish the relevant meaning relations.

While interactional strategies of thematic development are based in the exercise of options in a particular interactional situation, as in the previous examples, thematic development itself is most often not bound to local episodes in a lesson but ties these together by being spread over several of them, often noncontiguous ones. In EL we find a number of uses of the common pattern of controlling thematic development in triad dialog through TQs; these in turn contribute to a global strategy of thematic development. In (1L1-15) we find teacher insisting that students locate 'sound' within a particular system of classification. The SAs variously identify it as a kind of motion ('wave motion'), and kind of wave ('sound wave'), and as something that could be a kind of either one ('vibration'). In each case there is a TPosEval, then a restatement of the original TQ or a follow-up TQ which retroactively downgrades the TPosEval to a T-1/2PosEval move, and in the cumulative effect of the sequence, to a TNegEval, since none of the SAs uses the particular system the teacher will accept. In each case the secondary TQ insists that whatever thematics the SA uses is itself subject to a further subclassification ('What kind of...?'). But while the teacher thus acts to control thematic development, he does not directly advance it, introducing no new thematic links (no 'clues', no 'help'). The seeming dead-end here is avoided by a very deft metacommunicative move by a student, which identifies the relevant classification system ('those four'), enabling finally the construction of the global thematic relation (which is nowhere explicit in the dialog, though the teacher will later write it on the board): *Sound is a longitudinal wave.* In a later episode (4L3-5L7), we find the teacher using dialog-for-monolog as he constructs at the board and then through the TPreps and TQs of triad dialog a particular set of relations between the movement of a compressional pulse down a long coiled spring and the movements of the segments of the spring itself (*wave-medium relations*). The teacher uses triad dialog here to establish an extended set of alternatives to the usual 'right/left' contrast pair which are needed in this thematic system (see section 4 below). Cater, at (6L23), having meanwhile discussed longitudinal waves in general, the teacher asks for an example of one. It takes about four minutes and a strong hint to get 'sound' as an SA to this repeated question (8L16). The teacher then discusses the propagation of sound waves through air (*wave-medium relations* again), re-establishes that sound is a longitudinal wave (9L23-4), reviews the wave-medium relation for sound (to 11L7), and then asks a nexus TQ (11L8-10) which ties together the various strands of this thematic system.

In EL, at (8L16-19), when the teacher did finally get the desired answer 'sound', we find an instance of another very common teacher strategy of thematic control. The monolog-as-dialog strategy has a weak point: unexpected or unwanted SAs--indeed any less than 'perfect' SA which does not complete the underlying monolog development. At 8L16 students provide the teacher with a variety of answers (and do so in a way that violates the behavioral norms for this situation). He picks out the one called for by his line of thematic development. Selecting an SA, as a mode of thematic control, is one way in which teachers use SAs, rather than merely letting them stand or evaluating them. Teacher may do this and still retain the interactional control of speaking-turn assignments in triad dialog by a strategy which enables teacher to select an SA from several offered, one at a time, by duly nominated students. We have noted this strategy previously (Chapter 1, section 7) as one in which teacher withholds final evaluation of each SA, leaving the original TQ 'on the floor', and getting a series of SAs. In LG (1L13-2L1) 3 students answer, then teacher acknowledges the diversity of SAs ('a lotta ways to describe it'), marks what is important ('the key idea'), and states an answer to his own TQ which picks up on the first SA ('things') and actually reverses its sense (SA: 'things affected'; teacher: 'things that have an effect'). The SA was selected (the other SAs were not thematically linked to teacher's answer), and modified. Later, at (9L27-10L17) we see this again. Four students answer, each of the first three get weak or neutral, non-negative TEvals, followed by new Norms, until teacher gives a strong TPosEval ('Exactly!') to the last, selected SA. Teacher then restates this SA in four variations: a colloquial variant, an elaborated one, an unmarked one, and a formal variant of the third. (See Section 3 on variants.) We find similar phenomena in SC at (2L14-3L4), where teacher uses more complex TEval moves, and modifies the third SA; at (3L9-19) where he gets nothing usable and gives his own answer, and at (5L28-6L15) where TNegEvals are used and teacher totally changes Monica's answer in 'restating' it. Modification occurs without selection as well (cf. LG28-3L2).

There are a number of other ways of using SAs for thematic development other than selection and modification by restatement. We have noted in earlier chapters that when triad dialog is modified by having the TQ slot filled by questions from an external text, teacher relies more on the TElab move for thematic control. In such cases teacher may retroactively recontextualize an SA, placing it in a thematic context other than that in which it was given, or may simply take it as a 'point of departure,' pivoting on it to perform a semantic modulation to a different thematic line of development. These strategies of course are not limited to XTXT Dialog situations. The thematic transformation already cited in LG(1L13-2L1) as having the effect of inverting the sense of the selected SA accomplishes this by the process of semantic modulation. The 'pivot' is both the common word 'things' and the semantic pair 'affected/effect.' While the spoken emphasis in both statements is on the former, the contrast highlights the latter. What is 'modulated' is the thematic context, so that in teacher's version 'have an effect' is made equivalent to '(cause a) change'. Anyone who has been plagued by the 'affect/effect' semantics of English will recognize how easily the modulation may be accomplished; and no one I hope will be worrying here about the 'correct' usage of these words or the 'correct' definition of 'factors.' The participants here are making meanings with the socially shared system available, and teacher is using specific discourse devices to guide thematic development from the initial (1L6-7) to the final (2L1-3). We have discussed here only a few of the devices in this passage.

An example of modulation in XTXT Dialog is seen in DRS (3L11-19). The TQ 'slot' is occupied by a read XTXT question (#7a). Following the nominated SA (3L13-14), we get TPosEval and a TElab in which first teacher adds in some further meaning relations of the thematic system of the question, precisely those of the previous episode (*represent/diagrams/theory*). But then he continues the TElab, using this opportunity to control thematic development (characteristically in XTXT Dialog, where TPrep and TQ are not available) by pivoting on 'most probably/most of the time' to achieve a subtle modulation from the semantics of possibility to the semantics of frequency ('99% of the time'). While it is again true that the semantics of the English modal system makes this transition easy (Halliday, 1981), making it in this thematic system is an important part of the system itself, i.e. of the 'concepts' of a quantum theory teacher has used an SA to say something other than what student said by shifting thematic context, and teacher has thereby 'changed' what student said by putting it retroactively into the new context.

The strategy of retroactive recontextualization of SAs is the most general such interactional strategy of thematic development in dialog. A bit later in DRS, at (6L7-13) teacher radically recontextualizes an SA (and the whole preceding dialog) by saying at 6L13: 'Relativity! that's how Einstein made his fortune.' In the new context thus created, the themes of *relative motion* and *relative to the observer* enrich the meaning of what precedes and signal the existence at least of a thematic system that links the present discourse to other scientific discourses. The thematic shift in this case is so radical as to be humorous and playful. In Section 6 we will look again at the first episode of DRS where, at (2L12), teacher retroactively recontextualizes the unexpected answer 'Boron' to guide thematic development toward a satisfactory SA.

A more typical example of recontextualizing an SA is found in LG (4L7-17), where teacher alters 'earth's surface' to 'surface composition'. Two meaning relations are prominent in Scott's SA: *(surface quality)-(degree of)absorption/reflection* and *surface (insolation)-cloud reflection/absorption.* It is in the second that 'earth's surface' appears lexically, but this is not the theme teacher is developing here. Another student isolates this 'key idea' (21L13), teacher rephrases it (for writing) and gives examples which make the thematic context definite in a way that identifies the 'key idea' with Scott's first theme. The discourse device has acted as a sort of selection within Scott's answer, as well as greatly enlarging and shifting the meaning of the selected theme.

As a final example, consider the teacher's response to an SA at SC (4L19-24, and 26-7). The SA is not very informative because it omits a key meaning relation of the system. Teacher supplies this in (21L21) with 'marine' and then multiplies instances in this 'semantic field' (cohesion chain; 'marine, marine, fish, crab') to fix this feature in the thematic context. Teacher then himself gives an 'optional' answer to his own TQ, which we we may take as something like the meaning the SA should now have, after recontextualization.

2.2 Thematic Development in Teacher Monologs

In dialog patterns of interaction teacher must either control thematic development indirectly (as above) or share control in the students (see sections 5 and 6 below.) But during the periods of teacher monolog, generally brief in these lessons, we can observe the strategies of direct thematic development, a relatively rare classroom phenomonon wherever 'dialog' is preferred to 'lecture' teaching. We will consider the sittypes we have identified as TExplans, TDemos, TSumms, and TNarrs (see Chapter 1, section 6).

Teacher explanations, when they occur, do not simply provide information. They develop thematic connections which are often explicitly marked by 'logical particles,' esp. the colloquial English 'so' (cf. written English 'therefore' 'consequently'). Typical of these is DRS (8L16-23). In the TElab slot of XTXT dialog teacher follows an SA by first naming the 'rule' which provides an answer to the XTXT question. This conflutes an expected TEval with a T-Inform. Teacher then states this rule, continuing to inform, but using an 'if... then...' structure which subtly shifts into an explanation that has approximately the form of a syllogism functioning as an answer to the XTXT question. The underlying logic is an argument-by-contradiction. A new thematic relation is established, that between same quantum numbers and *being in the same place at the same time.*

The 'logical argument' format in explanations is particularly useful in teacher/student Debates, where an explanation may also function interactionally for teacher to 'win' and end the debate. We find a debating use of explanation at JR8L17-26 when teacher 'gets into geometry.' After using a meta to mark the explanation as utilizing a thematic system from 'geometry,' teacher develops relations among *area/ volume*, *circle/sphere*, and *relative rate of increase* (i.e. the 'scaling' principle). He then applies this to the situation at hand in the form of a logical conclusion ('so that'), linking it to the themes of the debate: *proportion* and *(cellulary) material*. The debate does not end. It does end in SC (6L15-25) when teacher states Hutton's principle of 'uniformitarianism,' explicates it by other locutions ('the same'), restates it, then applies it (or seems to) with the logical form 'so' to the issue of the debate, incidentally re-establishing a thematic link previously made by students ('looking' to 'prove'). We will return to this example in the next chapter, but it is worth noting here that the device of explicating (6L15-20) following an Inform move is itself a significant strategy of explanation to stand beside the logical connecting strategies seen so far. Two thematic relations are presented as parallel, or equivalent in meaning (see sec. 3) in the context; the longer is taken as explicating the initial, first one: (A) *present-key-past*, (B) *today-same-the past*. We find a scheme of ABB^1, (So)A. B is linked to initial A by cohesion (eg. present-today, the past-the past); in the overall scheme equivalence is implied, so the remaining terms have an 'induced' relation, i.e. 'key' = 'the same as'. B^1 is clearly a restating of B, and thus B and B^1 together become the 'long way' of saying A, and the 'so' following by A again clearly marks the equivalence. The relation of explication is is also cued by the register shift from 'aphorism/metaphor' (emboidied in the terseness and use of 'key') in A to the rambling 'unmetaphoric', 'normal' B and B^1. One can compare the explication of 'the Hund rule' by 'that' in DRS (8L16-23), or the explication of 'It bottles up the heat.' in LG (10L17-21). This latter case explicates neither by 'equivalent restatement' nor by logical argument, but by a narrative mode. Teacher tells a story, with an implied chronology and succession of events. Pure metaphor in 'bottles up' shifts to colloquial metaphoric substitution (but with an obvious literal sense in this context in 'bumps', balanced--for the sake of marking this explanation as important (cf. 'Exactly': above and the use of the board diagram)--by the technical register marker 'upper' atmosphere'. Finally we get a terse restatement that replaces the metaphor with an unmarked synonym. Teacher in fact goes on to write on the board another written register synonym 'retain' and calls attention to these variants by glossing.

The narrative mode of explanation, of course, operates independently of its role in such explications. Consider EL (8L21-9L16). A new episode begins. Teacher marks it as (1) a continuation from yesterday, and (2) as pertinent to a similarity relation between waves along the coiled spring and waves in air. The narrative explanation will be accompanied (cf. LG above) by use of a board diagram. We will see much the same pattern of explanation in a TDemo below; the diagram functions here as if in lieu of a visible (cf. 8L24-6) demonstration of air waves (i.e. of sound). Teacher informs the class of the conventions of his diagram (8L27-30), shifting into the narrative (8L29-9L2) as he drops reference to 'dots' and 'lines' and speaks only of molecules as they are before a sound pulse occurs (initial state of the narrative story'). The narrative mode then continues as Teacher describes a series of events 'compressing' and 'stretching apart' the molecules, illustrating these events at the board (9L2-12). Finally he states the similarity to the coiled spring (9L12-15). Teacher has 'demonstrated' a canonical way of describing sound in molecular terms using the narrative mode. He has used and developed a standard thematic system of 'science', by in part relying on features of the linguistic system and the 'diagram representation system' to build meaning relations in terms of which *spacing of dots* can be connected to *compression of air* and *sound pulse*. Teacher has also relied on the Narrative System by which we interpret narratives of a succession of events, and which as a discourse system is more like an interaction structure than a thematic system. It is a very deep mystery how 'explanations' are achieved in this (or any of the other) ways we have described; i.e. how precisely the contributing or base systems are used to develop the thematic system thru which things can be said that count as explanations. We will consider this in somewhat more detail in section 6 below.

An explanation that is accompanied by a visible demonstration occurs a little earlier on in EL at (7L9-8L1). A student has proposed telephone signals as an example of longitudinal waves. Teacher gives a clear NegEval (7L9), softens this by indicating that students are not expected to know why and that the error is an understandable one. He states the student's erroneous presupposition (2L10-11) and informs the class that it is not true, then offers an alternative (2L11-12). His alternative, however, ('back and forth') fits the definition he has given of longitudinal waves. To prevent confusion on this point, teacher must develop the thematic system, different from that used so far, which *does* describe telephone transmissions. After a pause he does so. First we get an utterance that connects back a few lines: (7L12-14) 'you might not *believe* this ...' to (7L10-11) 'I know you might think ...'. Both these lead phrases (theme of: *(folk belief *vs*. scientific truth)*) and the implied logical relation (i.e. electricity can't go house to house because electrons travel so slow) connect these. So incidentally does the *self-correction* contrast of *electricity *vs*. individual electrons,* cf. 7L13 and see sec. 3 below.) Their relation prepares for an explanation of the 'because' type. Now comes the demo. Teacher lays the window-pole along the top of the demo table, one end projecting about a foot past the edge near teacher, and punches it several times away from him. The demo is treated *analogically* (cf. 'like that' 7L26), still another basic mode of 'explanation.' What counts for teacher as 'explanatory' is the description of electrical transmission in the thematic system which the demo represents analogically, namely 7L19-22 as teacher himself states it, with the marker 'so'. Note that 'so' tells us it counts for teacher as an explanation, not that any argument recognized in formal logic is being made. Having established this new thematic system, teacher finds himself still in trouble. He set out to show that electrons go slow; his demo shows a fast pulse. He now proceeds to answer in advance this objection (with the very form of prolepsis in classical rhetoric!), but in fact focuses on the pulse, arguing it down from 'instantaneous' to merely 'the speed of light.' He asserts again that the individual electrons go slow, but his new thematic system has not gotten the crucial meaning relation built into it (the electricity vs.individual electrons contrast), since there is no analog of this in the demo. *Implicitly* pulse has been identified with *electricity* and *current* as that which goes fast, contrasted to *individual electrons*, which go slow. Analyzed by us the thematic systems of 'formal logic' or 'electrical physics', there would seem on the surface to be no completed explanation or fully developed logic at all. But much of classroom discourse is like this. In the next section we will discuss the importance of such subtle and often crucial cues to the implicit meaning relations in terms of which alone the discourse 'makes sense' as that self-correction at 7L13.

Note that TDemos as a sittype more often use dialog interaction patterns than TMonologs and our interest here is not in demonstration as seen but in the modes of explanation that we can identify in such situations. So also with Narratives, tho in these there is an intrinsic feature of monolog control of thematic development. The TNarr in JR (1L12L1) does not function as an explanation in any sense (nor does EL's 'frozen goose' story), but we will consider it in section 6 below as an instance of thematic development by narrative when students do not yield full control to teacher.

We conclude this section with consideration of monolog thematic development strategies in TSumms. At LG (8L12-15) we find a very brief summative statement by teacher closing an episode that began at (6L27) with a written TQ, read out as 'how does our atmosphere .. become heated.' The thematics of the discussion has diverged twice, once briefly as teacher introduced a 'mystery' (his 'very special name' 7L12-5) and again more persistently in the discussion of heat mirages (7L23-8L11). Teacher now says simply 'the ground does give off heat .. and that's how our atmosphere is heated.' He then shifts sittype and introduces a new task. The summary serves to select the major thematic relations in the previous discoussion. The emphasis on 'does' reaches back not only to the heat mirages as evidence of this fact, but back to the debate with Erin (5L20-6L22), who challenged this assertion. The emphasis on 'heat' recalls the confusions (3L4 seq., 5L10 seq., and in the debate episode) over use of the *light/heat* contrast relation. Finally, the pause and emphasis on the question-word 'how' recalls the original question and selects the previous clause as its acceptable answer. We identify these as strategies of selection, foregounding, and connexion, with an implied backgrounding of the major, omitted themes. A second short summary of this kind occurs at JR (7L5-9). What is being summarized here is the students resonses to a question first posed at 5L20 concerning possible problems of people in a very large crowd, itself an analogy to the problems of a very large cell (cf. 3L10-12, 5L6). Teacher reviews a series of three accepted, discussed answers to the 'crowd problems' question. Emphasis is put on 'food' (cf. 6L20-7L2) and 'air' (added spontaneously, 7L8, but part of this thematic system) and probably is not needed on 'wastes' (cf. 6L1-18). Topical emphasis (by first position in the English clause, cf. Halliday, 1976 cf. MARM) falls on 'people in the middle,' a thematic contribution of teacher himself (at 6L14, with emphasis there), repeated by him at (6L18) 21, 27, and developed by him in both the 'waste' and the 'food' problem, esp. in the latter as part of a *middle/periphery* relation. That thematic relation is crucial to the ultimate argument, to the wider thematic system in which the relation corresponds to *cell nucleus/cell membrane-environment*. (cf. 10L12, 17, 22). In fact teacher immediately returns the discourse analogically to the cell (7L9-10) and to its 'outside edge' (i.e., *periphery*). 'Summary' has already ended, but teacher's monolog control is soon surrendered to students' bids to resume dialog (7L11,13) and the debate resumes. Again we have seen selection, foregrounding, and connexion (in this example both backwards (anaphoric) and forwards (cataphonic), tho we step beyond a simple notion of 'summary' in including the latter here.)

At 9L28 teacher initiates a major summary of the Main Lesson so far. Again he is providing an answer to the original question ('Why is the cell's size limited?'), which Robert has asked him in a bid to end discussion (9L3,5). Hence the (ironic) emphasis on 'your'. Teacher begins to select the theme of 'proportions,' which he tried to explain in the *geometric scaling* thematic system, but which has construed to be a focus of confusion and debate. He corrects himself and selects instead the *center/periphery* theme and its links to the 'problems' of food and 'oxygen' (cf. 'air' above); 'wastes' is backgrounded by omission. We get the logical 'so' with emphasis 'can't' reflecting the original issue, not of why but of whether the cell's size is limited. This return to the very first issue of the episode (*whether*) is echoed by Mr. Y in recalling 'the Blob', the thematic system in which *whether* was posed and which has not been invoked since (4L3). Teacher now makes a major (anaphoric and cataphoric) connexion of *cell size limits* to *cell division*. Teacher announces and writes the 'Aim' for this lesson, rejects an SQ, and now proceeds to a second summary, this one written on the board, giving it the strongest marking as 'important', and 'official'. The themes in this 'official' summary, (10L11-23) are still: *cell size limits*, *center/periphery*, and *growth/difficulty of transport*. It is the last of these which is still under development in this summary. Teacher has made the 'food and oxygen' theme very prominent, but these are only examples of the general problem, and now teacher replaces them by more abstract locutions, colloquially: 'things it needs to stay alive' and in written form: 'the necessary materials'--which is ten glossed by the examples 'food, oxygen' (10L23). The effect is to background these and relatively foregound *difficulty of getting necessities*. The missing example 'wastes' does not so neatly fit teacher's thematic formulation, and the concept of *transport* as such, while implicit in the discussions has not been foregrounded explicitly in the summary. But teacher has modified the thematic system slightly in his summary in a manner similar to what we found in the dialog strategies. The summary retroactively pulls together all that it summarizes and functions much like a TElab comment on the 'macro-dialog' it defines.

Finally we mention two summaries in EL. One (5L8-6L10) shifts from a colloquial to a formal written summary and teacher continues his thematic development despite two shifts back into dialog. The other (10L28-11L7), following a rather 'high pressure' review, recapitulates the narrative explanation of sound waves in molecular terms (8L9-9L12). Comparing the passages we see first that the orienting metas for the use of the board diagram do not reappear (backgrounded)--and this is not automatic, cf. DRS in which the diagrams themselves are foregrounded (passing)--and the analogy to the coiled spring is also omitted. Structurally we are led to the important thematic relation *no sound/still air* by the comparison (anaphoric connexion). The modality has shifted from what does happen to what must happen, an emphatic device. Finally we get a 'so' thru which an implied connexion of logical necessity is made to the thematic development of the intervening episode (9L16-10L27): *medium moves back and forth*, in effect a synthesis. Note particularly that, simply read as a statement, the summary (even with teacher's pointing to the board diagram) would not convey much meaning apart from its connexions with the full narrative explanation. Even when monolog 'explanation' does occur in these lessons, redundancy--in the sense of repetition and representation in variant forms of the same meaning relations--is essential to the development through the discourse of a thematic system. And not merely the separate instancings of the relations, but their interrelations. thus there is not so big a gap as might seem betwen thematic development in extended explanation and that which occurs continuously through the local and global interrelations of smaller discouse elements, for even where the former do occur in science classroom discourse, most often they do not 'explain' autonomously, but like the latter merely contribute a bit more to the gradual construction of a thematic system. In the next section we examine the principles of this construction on their own terms.

3.0 Systemic and Structural Strategies of Thematic System Development

A thematic system is a system of meaning relations. While these relations may be themselves subcategorized in many ways, or all subsumed as variants of the general meta-redundancy relations of meaning systems, it is useful here to examine them in relation to the most common and most important devices by which they are built up, especially the discourse devices (including non-verbal actions where they are integral to these discourse functions). Most frequent and basic are the ways in which representatives of themes or relations are treated as either *equivalent* to one another in the context, or as *contrasting* with one another in that context. These relations are *systemic* (cf.   , Halliday) or paradigmatic in that they define the systems of alternative choices in some *structural* (syntagmatic) setting. Against a background of equivalence and contrast, and thus a hierarchy of categorizations, *similarities and differences* may be foregrounded by *textual transformations*, i.e. similar and yet different variants or versions of saying 'the same' thing; from exact repitition (in necessarily different contexts) to restatements, reformulations, paraphrases, and even contradictions, where both the similarities and the differences, the invariants and the transformations are foregounded thru the *relations* of the discourse 'texts'. But those relations have *structural* as well as systemic dimensions; one comes first, another follows. The notions of 'repetition', of 'correction', and of 'the last word' or 'definitive version' depend on *structural* relations. The small scale *structural* relations of discourse are partly described by *syntax* (while the *systmeic* relations define context-dependent 'semantics'), especially clause grammar. But syntactic choices can form global patterns (e.g. same vs. different tense in successive sentences) as well as function locally, within the clause. And there are other 'text building' resources of discourse, such as cohesion chains and their interaction (Hasan's work). Finally there are discourse resources which are not limited to operating only within a text or occasion of discourse, but form links between texts and across episodes, lessons, or even genres or settings (intertextuality). Indeed this is a principal function thematic systems themselves. In this section we will survey some of these discourse devices of thematic system development. If 'science teaching', as I am suggesting, is best understood as thematic system development thru (actional) discourse, then this section looks at some of its most basic forms.

3.1 Equivalence and contrast

In JR (8L20-22) we find instances of establishing both thematic equivalence and thematic contrast relations for the same term, 'sphere'. First there in an explicit contrast (using a meta, the least common technique) against 'circle'. Formally we have 3 features establishing the contrast: the meta ('we're not talking'), the parallel environments ('we're not talking about...'), and the emphasis ('circle' 'sphere'). We will return to contrast devices after surveying some of the equivalence devices, but note that even a contrast ties the contrasted elements into a common thematic system in which 'circle' and 'sphere' have some definite relation to one another (cf. DRS 6L20-30). Although *backgrounded*, this system is *invoked* by the contrast. Such *implicit thematic systems* are important to thematic analysis and often later become *explicit* in the discourse. Neglecting their implicit functioning obscures antecedents when they do become explicit, and misses key elements in their *construction* thru the discourse. Immediately after '*sphere*' we get an *equivalence*: 'OK? a *ball*.' This *appositive* construction, and the repitition of the *emphasis*, establish the equivalence. The equivalence is carried on in that 'ball' is used twice more where, from other texts on this on this topic (teacher invoked this intertextual set in 8L18-19 with 'geometry'), we would usually find 'sphere'. This is an instance of *local synonymy*. The lexemes 'sphere' and 'ball' are completely substitutable in *this* segment of *this* text. The same equivalence device occurs at KF 13L28), where apposition equates 'Oh-two' and '*oxygen*'. The *emphasis* in '*oxygen*' serves to foreground the morphemic similarity, and the phonological resemblance to 'oxidizing'--*not* shared by 'O_2' as read "oh-two".

Appositive constructions can establish more specialized equivalences than local synonymy. For example in EL (4L17-18) where 'the medium' is equivalent to 'the spring itself', '*but*' only when speaking of waves on the spring (and not of sound, when the medium is air). Just below this (4L20-21) is an equivalence induced not by apposition, but by *parallel and* similar environments, as well as the metaphoric use of 'becomes', equating 'particle' to 'piece of spring'. This device is seen again at KF (2L1-2) in the equivalence of *lose* to *beminus a*, where it appears in the guise of self-paraphrase. The first locution is intertextually standard, the second not. SC (3L21-23) provides an example of a complex double appositive construction. The first term 'shallow water fish' is glossed by the relative clause in first apposition, and its 'shallow waters' is then glossed by the second apposition. It may not be necessary here to let students know that it is the waters, rather than the fish, that are shallow, or to define the local meaning of 'shallow', but these devices are available to do the job. This example also illustrates the structural dimension of the discourse device, its use of sequentiality and of syntactic structure patterns to function as it does. These 'glosses' of course are not metas (at least explicitly, in their forms), but clearly definitions, normally explicitly metacommunicative, also establish equivalences, as at SC (4L28-30) for 'uplifting', incidentally showing that definitions here are a functional, not a formal category.

Equivalences are not just monolog devices. At EL (3L10-13) in triad dialog, both the device of parallel and similar environments, and the presumption in triad dialog that when teacher restates an accepted SA the SA and the restatement are equivalent, establish an equivalence between 'a wave' and 'a pulse', where teacher has kept to the underlying monolog form of 'the answer'. Again in triad dialog (LG4L22-4) we find a student altering the TQ locution in her answer. The TPosEval establishes/confirms the local equivalence of 'surface area' and 'ground'. Students emphasis on 'ground', despite the fact that 'gets hot' is the answer to 'what happens', may be a bid for thematic control, rejecting 'surface area' as unnecessary use of technical register, and it may assert, seeking confirmation, that 'ground' really is what teacher was asking about, i.e. is equivalent to his 'surface area'. (As usual in microanalysis we describe meanings-for-some-participant, i.e. meanings possible in the classroom meaning system, not 'conscious intentions' attributed to these participants now.)

A more complex dialog example is found in EL (3L17-21). Similar and parallel environments (and chain interaction) over this dialog establish an equivalence between teacher and students 'move' and teacher's 'wiggle'. The modal contraries, with emphasis ('it's not ...' 'it is' 'it did') establish at least that 'wiggle' is evidence for 'move' if not equivalent to it (as a kind of motion). The complexity increases at (3L24) where 'move' is contrasted with 'travel' (*spring moves, wiggles/wave travels*). The thematic system being developed globally in this lesson uses several additional meaning relations to categorize the motions involved. Thematic system development, although here we are looking at some of its discourse devices locally, proceeds non-locally thru the implicit *relations* of separated bits of the discourse, equivalences *and* contrasts, and their contextualizations. We will look at extended thematic system development in section 6.

Some final examples of *equivalence* will show the kind of complexity they can contribute to. In SC (1L6-8) we find an apposition-like series fo 3 TQs, each re-stating and presumably equivalent to the others. The *intonation* pattern here has no contrastive, self-correcting, 'changed my mind, here's a different question' features. This is a new teacher, who is still working on his 'questioning technique'. Comparison of the three versions gives a preview of section 3.2 where we will examine how repititon with variation serves to construct thematic systems. The first version uses the 'transparent' passive voice usual in technical register; one does not even think to ask what *agent* forms fossils. The second version is very colloquial, but also quite unspecific--it could as easily be answered with a definition of fossil (already given as an SA in 1L2), characteristics of fossils or fossilized organisms, etc. The third version is almost bizarre in this context. The 'if...then' construction does not represent any underlying logical implication; 'you want to be' has a personal, almost 'imaginative fantasy' quality abnormal in the register (cf. Chapter 5); and then the '*done* to you' construction makes the passive vivid rather than transparent and *invites* an agency question ('Who did it to you?') It is also grammatically appropriate to only one of the two responses teacher expects (cf. 1L19,2L1), tho it fits a rejected SA (1L15-16). The other agrees with only version 2 of the TQ ('have hard parts'), and indeed we can see retrospectively that version 1 unites versions 2 and 3, each of which is appropriate to elicit a different part of the expected answer. The meaning relations implicit in the three versions build-in those of the thematic system cataphorically with respect to the expected answers, thru an awkward but revealing monolog-to-dialog transformation: *Fossil formation: to be one it takes 'Hard parts', conditioned on 'being bored quickly.'* A slightly less complex but similar equivalence is built by the double question at (2L14-16) which tells students that the answer to 'how' is 'what we said', which functions in part to mark the 'how' question as review, or its answer at least as 'old info' (see section 4) and to signal an intextual relation to a previous lesson's discourse and the students' own notes.

Finally, in triad dialog we encounter in DRS (6L7-13) an implied equivalence achieved thru the triad structural pattern that contributes, in part intertextually, to the construction of a 'science' thematic system linking the local discourse to a very different topic, (tho that 'invoked' system remains entirely implicit). TQ poses an exclusive 'or' problem. Several SA's realize the theme *it depends on (the observer)*. The obligatory TEval is conflated with a TElab; the TEval is positive, so the TElab is taken as equivalent to the SA. It is 'Relativity!', which in itself names the SA theme and in an 'advanced science' context bids a link to the usual use of the term in this register, carried thru in the independent TElab mentioning 'Einstein'. In fact there is ample warrant in the thematic systems of theoretical physics not only for the link thru the SA theme, but for the wider thematic relations of Einstein's Relativity Theory to electron spin.

We turn now to an examination of common discourse devices to establish contrast. A fairly explicit and simple device (cf. JR8L20-21 above) is that of JR5L3-5, occurring in student-initiated dialog. A student proposes that some one-celled organisms are 'from plants', and teacher responds 'No. Those're animals.' The simple contrast here is plants vs. animals, achieved thru parallel constructions ('they come from ...' 'Those're ...') and the sign of contradiction, emphasized ('No.'). But more is happening here. Why the emphasis on the original 'plants'? and the 'Don't they ...' construction, itself presupposing a contrast in its function as Challenge? The student's last utterance (4L29) emphasized 'person' and was contradicted by teacher to contrast *cells-within-an-organism vs. single-celled organisms*. A complex system of contrasts is being developed here in which the contrast between 'plants' and 'animals' is not simply the generic semantic contrast, but a local contrast. Specific to a thematic system whose meaning relations are being built here. We will examine this in detail in section 6.

A fairly common and quite indirect contast structure is that of self-correction. for example in DRS (14L20-21), teacher says first 'f shells' then restates substituting 'f orbitals'. Again we find, as with equivalence, the use of similar environments ('... being filled up.') but the pitch contour signals contrastive stress for 'orbitals'. In the global thematic system to which 'shells' and 'orbitals' belong, these terms do contrast, and 'f shells' is not a well-formed phrase, while 'f orbitals' is. But that global system is being constituted by such self-corrections, which are in part how we learn that 'f shells' is unacceptable. More explicit, but functionally the same is the later self-correction (17L12-15): 'is the outside orbital .. uh .. wrong ... is the outside shell'. Again the similar environments, but this time we have an explicit marker of contradiction ('wrong') with emphasis and contrastive stress on 'shell'. This sort of implicit constitution of features or the meaning relations *shell/orbital* is far more frequent than explicit discussion of the relations. Notice, incidentally, that teacher's 'wrong' has the form of a TNegEval directed by teacher at his own speech, reflecting the dialog character of all, even monologic, discourse (cf. Voloshinor), and creating a certain solidarity with the class, while sustaining the ideology that some independent Truth Rules, rather than identifiable social communities, determine when TNegEvals should occur, i.e. "we're solidary in both being subject to the same Truth

Rules". We will see in section 6 a complex example of this social construction of 'truth' in an episode from KF. One dialog instance of the contrast that is negotiated there is found in a prompted self-correction KF(1L19-20) by teacher: 'gained' vs. 'lost'. Students also contribute self-corrections, as at (2L7-10): 'negative four' vs. 'plus four', and again this contrast is part of a complex, specialized thematic system (*gain/lose*, *positive/negative*, *plus/minus* and their use relations in this particular system).

An interesting dialog device to establish contrast is teacher selection from among several SAs. The TPosEval of the selected SA contrasting it with the implied TNegEval of the others. Thus in LG (5L12-15), the final TPosEval of 'Heat energy'--itself with contrastive stress--fixes the contrast to 'light'. This meaning relation, again one very specific to the local thematics (and not simply a universal semantic contrast) is a major construction of this lesson, treated in more detail in section 6. Note that the T 1/2PosEval 'Yeah. originally' to 'solar energy' sets aside this answer, which does not fit the contrast system. The contrastive stress on 'originally' in part means 'that's not what's foregrounded now' and in part 'that was true in our discussion earlier, before we got to the present issue'. We have another example of contrast by selection among SAs at KF (5L22-27).

At the beginning of the Main Lesson, LG introduces a new theme, and already foreshadows a contrastive system, at

(1L6-7) with contrastive stress on 'terrestrial.' The common environment is 'radiation' and intertextually, based on the 'wrong' answers to the meaning of 'terrestrial' at (2L8) and (2L13-14), we can supply the contrast *terrestrial radiation/solar radiation* and *terrestrial/celestial* respectively. Contrast relations do not function as isolates, but as parts of global systems, even when a local use may seem isolated. Thus in DRS (8L24) there is contrastive stress on 'space orbital' and no contrasting term actually appears in the discourse. The question is from an external text and there, or elsewhere in this register, one will find 'spin orbital' as the relevant term, but the *space orbital/spin orbital* meaning relation system is invoked by (8L24) and in use from *8L14-30).

Contrasts are also established by lists or series in which, within category equivalence (that they belong to the same list or series), the individual members are none the less distinguished. We find this at DRS (11L1-2): 'orbital notation, electron configuration, and electron dot'. The series mutually contrasts all its three terms, and the contrastive stress on 'dot' further emphasizes the contrast between the last two terms, which share the common environment 'electron...' and which are similar in their uses in many contexts. These contrasts continue to be developed in the episode. At DRS (15L20-24) we find a series: 'Chlorine, Bromine, and Io-deen' where teacher's deliberate use of the (local dialect) non-standard pronunciation, rhyming all three terms, stresses their series relation. Students then play with the pronunciation, creating a local occasion-bound contrast 'iodeen/iodayn' neutralized by the equivalence at (8L24). Teacher uses this contrast-equivalence pattern as a metaphor at (17L8-10) to strengthen an equivalence (made explicitly at 17L6-8). Pattern similarity is a general discourse device to which series relations often contribute. Thus the series pattern of 'Chlorine, Bromine, and Iodine' becomes a model or template for the later analysis of 'Copper, Silver, and Gold' (19L18 seq.). The restricted equivalence of their series contrasts helps build the main thematic system of the lesson, *chemical periodicity*.

By a complementary process, listing may foreground what the listed items have in common, serving to establish a generalization as in EL5L8-10 where the list defines media thru which 'sound' propagates in the same way.

There are many other devices, esp. non-local ones, in which contrasts are established, and we will consider some of these in section 3.3. The general characteristic of these non-local devices is that terms occur in contrasting environments. Indeed, if a strong local contrast of terms has been established, the terms may also polarize the environments in which they occur, creating an induced contrast between them.

3.2 Repetition and Variation

It often happens in classroom discourse that 'the same thing' will get said twice or several times in the lesson in 'different ways.' Here the notions of 'equivalence' and 'contrast' operate at a higher level of abstraction and over longer segments of discourse. Such segments 'invite' comparisons: their invariant features foreground their differences and the relations between those differences (transformations) function to build up the meaning relations of a thematic system.

Consider SC (2L12 to 4L30). In this episode a few thematic relations are states and restated by teacher and also by students. Occasionally students diverge thematically and teacher acts to maintain his line of thematic development. We will only highlight a few of the transforms and invariants at work here. In 2L12-14 teacher 'pivots' on *fossil*, the theme of the preceding episode (1L1-21LL); uses emphasis to link 'fossils' and 'evidence', the key thematic relation of the Main Lesson (which begins here), whose second term is the proposition 'the earth's crust has been moved.' The next episode will be a debate over the issues of 'evidence' and 'proof', and then the lesson will turn to other kinds of evidence for the proposition. Teacher now transforms his oblique assertion into a double question (see sec. 3.1), leaving the proposition invariant and making a minor shift from 'we were talking' to 'did we say' that implies the earlier general intertextual reference is now to be taken as specific, and 'used as evidence' has become 'help us know'. The emphasis helps link 'evidence' and 'know' in a cohesion chain that includes 'determine' (4L15) and 'suggest' (4L28), and which is the focus of the following Debate. The third variant (4L5-6) retains 'help' as an auxiliary that incorporates the fondness of scientific discourse for cautious, qualified, 'hedged' statement, epitomized in the final variant's (4L28-9) 'suggests'. The local meaning of 'determine' would be quite indeterminate in textual isolation, or even in its immediate context, but using the thematic system variants noted here, we could reasonably expend it as 'help (us) determine (that there have been) minor changes, etc.' as opposed to the otherwise possible 'help determine (which) minor changes, etc. (will occur) or 'help (us) determine (which) ... (have occured).' Variant three also transforms the proposition, keeping invariant only the phrase 'the earth's crust' and establishing an equivalence between 'has been moved' and 'minor change.' In the fourth variant (4L27-9), we get several transformations. The additions reflect new thematic relations, 'suggest' is officially cautious, and now 'the crust has been uplifted.' 'Uplifted' is added to the chain of 'minor change' and 'moved.' The emphasis on 'uplifted' functions here both to foreground a new technical form, defined imemdiately after, and as a foreshadowing of its contrast with *subsidence*, which occurs much later in variant five (SC2:1L1-2), but which is implicit, if incomplete in (4L9-14) and was used by Tat (3L21-4). Variant five exactly parallels variant four (both are 'official' statement written on the board) and helps create a structure via similar patterns of *(type of) fossils are found (location). (This fact) suggests (the earth's crust) (in past time) (uplifted/subsided)*. Still later in the lesson, structures become evident in which 'fossil' evidence is replaced by 'earthquakes' and 'displaced strata' and the variants 'minor crustal movement' 'past crustal movement' and 'minor changes in the earth's crust' occur, the last as an inclusive term. These variants are building up a complex system of thematic relations of contrast and equivalence.

There are two other major 'repeated' themes in this episode. One provides the addition relations noted in variant 4, 'marine fossils are found in mountains of high elevation.' The first version of this is by a student (2L17-19) 'Lilie, if y'find fish fossils on top of a mountain ...' Teacher himself establishes the 'fish'-'marine' equivalence in his restatement (2L20-21) as well as that of 'on top of a mountain' with 'at high elevations'. Note that these are synthesized in the 'official' variant 4. In an overall comparison of teacher's restatment and the student's words, the style shift is also notable. 'Like,' indefinite 'you', and the tag 'or somethin'' are strong colloquial markers. Teacher's register, among other differences, has nominalized 'you find' to 'finding', depersonalizing it and backgrounding the issue of 'who finds?'. The other major repeated theme is 'subsidence', whose official version is variant 5, but which occurs in our episode first in teacher's version (3L21-4), and then in what we take to be a student's effort to state the argument. Teacher's version personalizes this time ('we might find'), uses oppositional glossing to explicate itself; tries to construct a contrast *shallow/deep*, but having used the term 'fish'--note that student's 'fish fossil' is not usual in the register--needs to emphasize fossils (in contrast with 'living fish'); and ends with a more colloquial 'that when the subsidence happens' which does not specify the relation to *evidence*, as variant 5 more nearly does. Variant 5 also nominalizes 'in deep oceans' to written style 'at great ocean depths', which among other effects the colloquial obscures the 'shallow' vs. 'depths' contrast by reducing the grammatical parallelism. Such a shift is not trivial for many secondary school students (cf. LG's careful morphological shifts at 10L22-3 and 11L 29-12L3 with the same class). Systematic missing of such thematic system cues by non-native speakers or non-standard dialect speakers becomes much more important as an obstacle to 'subject matter learning' in the discourse model of instruction developed in this report than would be expected in conventional theories of classroom learning. (See section 3.3 for additional discussion.) The student's version (4L9-14) is again nearly uninterpretable in isolation, or even in its local context alone, without its relations to the other versions. In a fully intextual analysis we would also include versions from the previous day's lesson and from the textbook. This statement begins with the colloquial signal 'like,' and if we compare it to the student version the first major theme (1L17-19), we see the similar indefinite 'you', the same locution 'if you find (...) fossils (location), you know that ... once ... there was(n't) water ....' These statements by different students occur five minutes apart, yet their similarities of detail are remarkable. The similarities reflect in part a 'way of saying' which is being used by students in this class, which is part of what and how they are learning the discourse of this thematic system. A third student begins an answer with 'if you find' (2L29), restated by teacher in the locution 'you might find fossils (location ... originally ...' (cf. 'once'). Some such similarity is expected if register constraints are as detailed as proposed by Halliday (1978). In this common frame the student has inserted 'underneath the ocean', then added 'deep in it' to emphasize the *shallow/deep* contrast; he uses 'know', instancing the *evidence* relation, and realizes the *changed past* theme as 'once'. What in this thematic system has changed in the past? 'The crust' But student's thematics of 'crust' probably has it equivalent to 'dry land,' so it converges with the *change in relationship to water* theme to give: 'where there wasn't water'. The student now continues the *change* theme 'and then when it--' but breaks off, presumably missing the locutions 'subsided' (or equivalent 'sank') not given by teacher (except in a morphologically different form at 3L24) until much later. He now backs up and repeats his last statement, shifting the 'once' into closer relation with it, and continues with a 'so that' construction to tie in -determine'--the newest locution by teacher (version 3), which is on the board--supplying the proper subject 'you', and winds up, by way of the 'originally' we have just seen functioning like the 'once' in another student's statement, developing the *change* theme already implicit in what he has said: originally there wasn't water, now there's an ocean. This student has not given what at first reading seems a coherent answer at all, but he is speaking the local language and operating the thematic system available to him. Had he used *shallow* or *subsided/sank* he might have produced a very acceptable statement, without *shallow* his fossils are not marine, but dry land organisms, which is not essential to the argument, but without *subsidence* he has no thematic link between *crustal change* and an ocean being there that 'originally' wasn't, as teacher seems to recognize (4L15-17).

For an example in another lesson let us look again at the repetition and variation in the discussion of compressional waves in EL. There are two major sets of thematic relations being developed, one is that of the description of compressional wave propagation, and the other is that of classification as a 'longitudinal' wave. We will mainly consider the first, which is established almost entirely in Tmonolog; the other is developed almost entirely thru Triad Dialog. At (2L22) teacher says 'If we take a spring, and we compress it, ... , you get a pulse to go down the spring ...' (The first omission is a move that reminds students they have seen this already in a previous lesson; the second directs their attention to a sketch on the board.) At 3L4-7 we get a near repetition. 'If you compress a spring ...' 'If you compress a spring, a pulse goes down that spring.' The 'we' has shifted to 'you' (thou it remains 'we' in the omitted repeat of the remainder), the initial clauses are condensed into one, and the 'pulse' has lost its character as a human product and become a pure phenomenon, backgrounding the connection between the action ('compress') and the pulse. This is not a trivial observation. An important part of the thematics of describing wave propagation is the analytic separation of the ongoing wave from its source. Waves and pulses 'travel' and 'propagate' without any human action. Ideally they can do so indefinitely, even if their sources cease to act. This is a set of meaning relations not ordinarily used in daily life but important to many 'science' thematic systems and assumed their discourses. At (4L3) teacher defines an *undisturbed* condition of the spring 'before anything happens': 'it's not stretched and it's not compressed', creating two contrasts: *undisturbed/wave or pulse traveling* and if disturbed *stretched/compressed*. The initiation of the pulse again has human agent 'I'. Teacher begins a triad dialog on the theme of back-and-forth motion of the medium, his key criterion for 'longitudinal' waves, but simultaneously develops (thru TPrep and TElab moves) the descriptive system for propagation: 'this particular particle (has) to move in order to get the thing to stretch' 'a moment later, as this pulse travels, this will be the stretched out part and this will be the compressed part' 'this particle here becomes that piece of spring there'. At 5L10, after generalizing by list to the category 'medium': 'it gets compressed, like that pulse in the ... spring, and it gets stretched. That compression wave travels thru the medium ...' Now the agents have vanished. The 'wave travels' and the medium 'gets' disturbed. The agentless system has some 'gaps': What compresses the medium? the wave or us? Does the 'pulse' get compressed? or does it compress the spring? The system with agents suggests additional possibilities, e.g. can we get a pulse to travel by stretching the spring as well as by compressing it? Are 'compressional' waves' distinct from 'stretch waves'?

The main theme returns at 8L21 where teacher begins to establish a high-level equivalence ('was the same sort of thing') between what happens in compressing the spring and in compressing air. Teacher introduces the theme of molecules and explains his diagram. Then he describes the *undisturbed* state of air 'with no sound at all', anaphorically connected by the similar discourse patterns and thematic relations to 'before anything happens', etc. in 4L3. The agent system has 'you make a sound pulse' 'you cause these air molecules here to move ... to stretch apart.' This is co-ordinate with 'this particle (has) to move in order to get the thing to stretch', with 'air molecule' for 'particle'. There is a similarly close comparison between the rest of these two passages, and both shift to the agentless locutions. Finally, at 5L14, the 'pulse ... causes the spring to stretch ... and compress'; the potential for indefinite self-propagation is built into the thematic system. We have already (in section 2.2) compared the final version of this theme in 10L29-11L7. The *undisturbed* condition is now realized as 'still' air. This variant is entirely agentless (or 'self-agenting'). (9L9-10) had 'as the pulse travels' a new compression occurs by shift of the molecules, omitting the time relation of (4L10) 'in a moment later, as this pulse travels', which is now restored (11L1) 'the next instant that pulse travels over here, so ...'. The 'consistency' of the variants builds the thematic system, globally; the transforms among variants establish dimensions of meaningful variation, the meaning relations of the system. Any one of these versions is likely to be obscure, confusing, ambiguous, even 'non-standard' with respect to careful use ofthe (intertextually) accepted system (i.e. teacher's 'errors'), but together, seen in their relations to one another, the variants do enact the patterns of a regular thematic system.

We conclude this section by considering a special sort of repetition-and-variation discourse: use of analogy. Analogy is a context-dependent, restricted equivalence of two thematic systems based on a partial isomorphy between the patterns of their meaning relations. In our last example, there was in effect an analogy made between sound waves and waves on a coiled spring, or more properly between the thematic systems for describing the propagation of these waves. The structural isomorphy there is so great we are accustomed to think in terms of some superordinate system (e.g.'longitudinal waves' or an abstract mathematical descriptive system applying to both sound and springs. At the other extreme is the analogy of the window pole to the telephone line (7L10-8L1), already discussed above, DRS (5L18-22) makes an analogy between a spinning electron in an orbital and a rotating earth in its orbit, and (13L8 seq.) of energy levels of orbitals to the cost of different hotels in a town. This latter is in fact made implicitly, as an extended metaphor, or 'conceit'. But in neither are the thematic system developed separately and then related (as they are in the spring-sound analogy), but one is parasitic on the other.

In JR we do have separate development of the *giant cell problems* and *crowd problems* systems, which teacher explicitly labels (5L6) an 'analogy'. A preliminary connection is made at (5L12-13), where some special equivalence is constructed between 'cell' and 'group of people' in the common environment 'think of a large ...' The main TQ is 'What problems would some of the people face?' (5L20). At (3L10-12, 17-18, U12-3) we had 'What problems would a cell (like this,

this big, huge) have?' The thematics of cells is out, that of crowds in, until (6L16), when an oppositional equivalence 'all these people, all this living material,...' generalizes to a category ('living material'), which includes people and cells. The locution 'producing waste products' likewise applies to both, tho more usually in the *cell* system. The *people* system then is developed further until (7L9) when there is a direct transition back to *cell*: 'The same thing would happen to a huge cell.' The term 'food' belongs more properly to *people*, but continues to be used until (7L19) where teacher says 'the food and the nutrients', a pair that in isolation might imply a contrast, but in relation to the *cell* thematic system globally is really a reminder of the analogical equivalence of the terms. A key thematic relation, as noted before in discussing this episode, is *center/periphery*. The 'problems' which are first those of the 'huge cell,' and then those of 'some of the people' or 'people,' become at (6L12-14) those of the people in the middle.' 'Middle' is repeated thereafter with 'poor people' (6Lk8), 'poor slobs' (6L21), and 'people' (6L26-7, 7L5). After the back shift to *cell*, a student uses 'middle' (7L17) to mean middle of the cell, and at (7L20) teacher transforms this (as he did food to nutrients) to 'living material in the center', then 'stuff in the center.' A student uses 'stuff in the middle,' adn later 'nucleus and the little stuff that's in there.' 'Middle/ center' had perhaps become a stylistic marker here, reflecting the norm of colloquial-style for non-science themes and student speech, written style for science themes and teacher speech. But this teacher mixes his styles, tho he has shifted away from extreme colloquial when shifting back to *cell* from *crowd*. The student continues to mix 'nucleus' and 'stuff' (tho the term 'organelles' is already available (4L19-21), at least in student dialog speech). Apart from such norms (see Chapters 4 and 5), we recognize from earlier in the lesson that *organelles* belongs to a thematic system students are only beginning to master--apart from their use of the word (cf. U15-22). Teacher himself goes back to 'material in the middle' at (8L26) and a student replies with 'stuff in the middle', clearly a style contrast. The *center/periphery* relation later gets realized as *insides/outsides* by both the teacher and students, but when the teacher returns to it in his final, most 'official' variants, we find 'the center of the cell' (10L12,22) and 'central part of the cell' (10L17-18). Such co-variation of style markers and themes, and the authority relation of teacher and students (the implied contrasts: *fooling around/getting serious* or *just talking/to be copied down*) express other important dimensions of the thematic systems teachers and students develop in the lesson, those that are most obviously linked to interactional relations in the classroom (see Chapter 5) and to social ideologies (Chapter 4).

3.3 Syntax, Cohesion, and Intertextuality

The systems of meaning relations enacted in a discourse may be analyzed from the syntactic relations within structures such as the clause, from the cohesive relaions that link neighboring and distant clauses (including linkage thru global structural patterns such as parallel syntactic, morphological, or phonetic-prosodic structures), and from intertextual relations that link different tests or occasions of discourse to one another. All of these kinds of relations are marked explicitly in our corpus, but these systems of relations operate co-extensively with all discourse, being only occasionally foregrounded. Just as no discourse is asyntactic anywhere (tho in special situations cohesive or even intertextual structures may function instead of syntactic ones), so no part of a discourse lacks cohesive ties to some other part, and no discourse has meaning in isolation from other discourses.

Efforts to separate syntax and 'semantics' have not been notably useful; that is syntax can be analyzed to some extent as a purely formal system apart from the meaning carried 'in' the syntactic structures, but at the price of ignoring or obscuring the meanings of different syntactic structures, and at best leading to a fragmented theory of linguistic meaning: a 'referential semantics' of the meanings 'in', a 'functional semantics' of the meanings 'of', and a 'lexical semantics' of word meanings to bridge between them. Cohesive and intertextual meaning, not to mention 'pragmatic' or situationally contextualized meaning must also be merely 'added on'. Unified theories of discourse meaning (including non-linguistic action) place meaning rather than form first, even in the analysis of syntactic structural relations (cf. Halliday). It then becomes natural to integrate lexical and syntactic choices, and to look at the functional contextualization of meaning situationally, textually (cohesively), and intertextually. The unified theory may be specialized for linguistic 'devices', but is semiotically general.

I have made these general remarks here to alert readers to the likelihood that a great deal more of thematic development may depend on what might otherwise be dismissed as matters of 'form', unrelated to meaning, than is usually supposed. The implications for educational practice are quite serious, esp. where students are non-native speakers, speakers of non-standard dialects, or otherwise (e.g. socio-culturally) significantly divergent from teachers (textbooks, etc.) in their implicit responses to conventional form patterns that constantly carry information about themeaning relations of, say, 'science' thematic systems. This is not good news. This kind of linguistic competence is not ordinarily under the conscious management of either teachers or students and consequently is difficult to change or adjust. As discussed in the last section, it is not only the pervasiveness of these highly implicit modes of thematic development, but the relative infrequency of maximally explicit *thematic* (as opposed to the relatively more common *interactional*) meta-discourse, that magnifies their importance in classroom communication.

Let's look first at an example from DRS (1L21-25). We are in triad dialog. There is a T-Inform conflating the TElab of the previous exchange and the TPrep of the next, followed by its TQ in elliptical form, an SA '*Two* electrons', and TPosEval by repetition 'Two.' There is a cohesion chain 'one electron/ *Two* electrons/Two', an implied contrast 'one.../*two*...', an implied equivalence '*Two* electrons/Two', a marking of what is important in the answer (the *number* 'two'), and a formal *separation* of the number (in TPosEval) from the noun (in SA and TPrep). This separation is achieved thru *ellipsis*, a common *cohesive* device (M&M) such that the *equivalence* ('Two' with 'Two electrons') is constructed at the same time a tie is made between this utterance (TPosEval) and the prior members of the cohesion chain by the *joint* effect of the ellipsis and the triad structures *functional* relations (by which 'Two' is recognized as a TPosEval, restating an acceptable SA). But now look at the next exchange. Again a TPrep, an elliptical TQ, an SA and a TPosEval by repetition. But teacher does not say 'Two' this time but '*Two* S', his emphasis marking the important contrast (One S/*Twp* S) without separation by ellipsis. The cohesive tie is by simple retetition. In the next, syntactically similar, exchange, there is again the full repetition and no ellipsis in the TPosEval. Ellipsis as a device is foregrounded, tho not made explicit, by the use of the elliptical questions in these (and only these) thru consecutive exchanges. It is not accidental, not a 'free variation' that ellipsis does not occur in the second two TPosEval restatements of SAs. It *cannot* occur there; a simple 'two' would be 'ungrammatical' in the 'science dialect' being spoken. The expressions '2S' and '2P' are *similar* in a specific way in which they *differ* from the expression '2 electrons'. *Syntactically*, the 'two' morphenic functions *ordinally* in '2S' and '2P' and is *bound*, prohibiting ellipsis, while the 'two' morphenic functions *cardinally* in 'two electrons' and is *free*, allowing ellipsis. *Thematically*, this set of meaning relations is important; the ellipsis and its underlying syntax helping to construct the ordinal meaning system of 'TermSymbol' expressions in contrast to more familiar cardinality relations. The conventions of the TermSymbol system are nowhere *explicitly* explained in the lesson; their use implies an intertextual connection, and somewhere, occasionally, in the 'intertexts' explicit explanation occurs, but everywhere in their *use* the system relations are only *implicitly* displayed. In this episode alone we have a complete morphology of 'minimal pairs' for the system's meaningful contrasts: 1S/2S, 2S/2P, 2P/2Px, 2Px/2Py, and each contrast occurs twice in the space of 9 lines of transcript. Moreover, the meanings of these contrasts are listed a few monents later in a brief *explicit* statement (2L20-21) *that does not mention any term symbols at all* and which is cohesively connected to them only thru a single *syntactic* link

(1L16) 'the 1S orbital' between the *'orbital'* chain and the *(TermSymbol)* chain. The *implicitly* displayed relations are thus: *1S.2S*, 'size' difference, *2S/2P, 'shape' difference*, and *2Px/2Py, 'space orientation' difference*.

Since meaning systems are constructed globally rather than locally in discourse, local (e.g. clause-internal) syntactic relations *contribute* to thematic development thru the (global) cohesive relations constituted between such (local) syntactic ones. Thus in the first episode of DRS the active voice, transitive, material process 'agent-acts on-patient' syntactic structure occurs only twice, in the first and last lines of the episode, with human 'agents'. These lines have many other textual, thematic, and interactional relations of similarity and complementarity, but syntactically they contrast with what lies between them, where a variety of passivized, intrasitive, agentless, non-material, purely relational (cf. Halliday, 1981) syntactic structures are used to present the 'science' thematic systems, while the end pair present the interactional practices of the classroom. In each separate clause of the episode the particular syntactic relations of the clause fulfill *local* functions in those clauses, but the *use* of some types of structures to present and develop some thematic systems and of other types for others deploys syntactic systems *globally* to constitute global meaning relations. In this case the contrast enacts features of an ideology (see Chapter 4). We have previously noted thematic development thru choice of modal verbs ('will' vs. 'must') in EL (pp. 8-11), and such syntactic choices carry an important implicit thematic relation in the DRS episode's 'could be represented' (1L18) vs. 'is being represented' (2L8), as they do for example in JR (1L23-2L1) where teacher shifts from 'does' in the narrative to 'can' in the discussion, later (3L3004L2) where non-foregrounded matters-of-supposition ('should') are contrasted with foregrounded implied-matters-of-fact ('could'). The pervasive role of 'contrafactual conditionals' in thematic development in JR should also be noted.

In KF a very important set of thematic relations depends critically on students' mastering particular syntactic structure, and especially the transitivity system of that structure. At (6L21-24), prompted by disagreement in resolving a possible ambiguity of the syntax in accord with the thematic system being developed, teacher uses a metalinguistic statement to identify and foregound the problem. In sec. 6 we will analyze this complex relation of syntax and thematics in some detail. Explicit discussion of syntax is fairly rare in the corpus, except for instances like that in LG (10L28-11L3) where teacher invokes a prescriptive syntactic rule in response to a student challenge which occurs just after teacher has foregrounded choice of language as such in (10L21-23, cf. 11L30-12L3). A quite unusual and most interesting explicit discussion of how thematic relations are carried in syntactic constructions, specifically the idiomatic use of prepositions in technical register discourse about electrical circuits, occurs in a university class on electronics for non-specialises, conducted in dialog modes than is usual in university science classes. There are 13 students. Teacher has called a boundary at 1:43:45 (Tape BN-EL-1 of 13 May 1980) to initiate a triad dialog review of what has just been discussed. The topic is translator amplifiers. Students have difficulty with the task of telling how to evaluate a quantity ('the signal input impedance') which is not given. Teacher advises them in a norm-violating way (see Chapters 4 and 5) to 'stop thinking' and follow the definition. In trying to get a student to state the definition acceptably, teacher asks for more specificity: 'What voltage? Where?', and when Mr. D answers 'thru the base of the transistor', teacher's reply is 'What was the proposition you used?' (1:48:16 seq.). Mr. D repeats his use of 'thru'; teacher gives a strong negative evaluation moderated by humor, and with responses from other students, establishes that 'thru' 'never goes with 'voltage'', that it goes with 'current', and that 'across' goes with 'voltage'. Teacher then further elaborates this idiomatic syntax system by noting that there is another preposition you can use with 'voltage', when there's ' a ground', namely 'at'. As teacher returns to Mr. D. the student tries using 'across', and teacher establishes thru dialog that 'across' requires specification of 'two points'. Student slips into use of 'at' at one point in this and teacher seizes on it, prodding the student to restate with 'at.' Since 'at' requires the specification of only *one* point, the student 'automatically' says it 'right' and teacher now resumes development of the *use of definitions* theme, ending with interlude on *prepositions*. Teacher has made far more explicit than one ordinarily finds some of the ways in which lexico-grammatical/syntactic structures such as 'currents go thru' *vs*. 'voltages are at (across, between)' carry thematic relations *implicitly* wherever they occur, and especially when their contrasts are foregrounded (by emphasis, by parallel constructions, common environments, cohesive ties or chain interaction, etc.).

We have already made use of the cohesive relations that tie texts together in all our global analysis of thematic development. We will deal with these connections and their role in thematic development further in section 6, but it is appropriate to mention here the cohesive pattern we call a thematic *nexus*. The chain interaction (Hasan's cohesive harmony) model of cohesion identifies 'cohesion chains' in which there are semantic and functional 'ties' between elements across a text, and structural syntactic 'interactions' between chains when at different points in the text the elements from two distinct chains are placed in the *same* syntactic relations to one another. Thematically the chains, or the themes realized thru them, have a meaning relation established globally thru the local syntax at different points in the text. At a thematic *nexus* several chains are brought into interaction for the first time, constituting a sort of thematic 'synthesis.'

Such a nexus occurs in DRS (2L5-8) in teacher's long and complex question (see section 6 for analysis), and in LG (4L19-24) in the triad exchange which brings together for the first time several major themes of the lesson (*earth/surface*, *abosrb/reflect* *light/heat*) in the principal system of relations being developed. We find a nexus TQ also in EL (11L8-11).

We will not deal at length in this chapter with intertextual strategies for thematic development (but see chapter 4 where intertextuality is treated in relation to ideology). The most important notions are these: that no discourse or text makes its meanings in isolation from other texts on occasions of discourse, that the intertextual devices of discourse assemble systems of discourses, defining both which discourses from mutually contextualizing sets and what relations of contextualization obtain among them, constituting the sets as systems. The sets may be assembled by invoking a thematic system whose relations apply in the different texts and which can induce corresponding intertextual relations. In a complementary way, the assemblage of a system of discoursees by other devices contributes to the development of thematic systems. These relations and processes are a special case of the enactment of a Meaning System (see Prolegomena).

Potential relations to other texts or discourses may be established by invoking particular thematic systems or by enacting a particular situation-type or event-type. When Having a Lesson is the sittype, prior lessons of the same class are potential intertexts, frequently directly invoked by mentions of 'yesterday' 'last week' etc. Different episodes that enact the same interactional structure pattern, e.g. triad dialog, or summary monologs, have a potential cohesion by structural similarity that is no different from the same phenomena linking episodes in different lessons. Any relation type, once established, can be foregrounded as the basis of an intertextual tie (e.g. their common 'humorous tone' may link two discourse episodes).

Reading these transcripts one encounters many indexical uses of language (e.g. 'look at this') which signal to us that there is information from the interactional context of situation shared by the participants but possibly unknown to us (i.e. what 'this' was). Similarly we may read the signs of shared thematic systems used by participants, most clearly clearly when these are explicitly invoked or being developed, but also when they are simply implicit in the discourse. And again there are points in the discourse when there are signals that some other text or discourse is relevant to the meanings being made, but which we may not be able to identify or do not have access to as participants do (most obviously, for example, in XTXT Dialog). In LG (10L9-14) teacher's mention of 'Mr. Scott', a student-teacher, places the preceding SA in the context of another lesson, in relation to which the SA is much more fully contextualized (i.e., more meaningful) than it seems if seen only in relation to the rest of this lesson. Indeed the *percent reflected* theme has no other textual connections in this lesson. Teacher's making explicit the link to another lesson also serves the function of thematic control: to direct students to a different thematic linkage than the one made in the SA, to the one teacher wants here in this lesson. A little later (12L19-21), the teacher uses a similar device to direct thematic development toward relations to another discourse. After the TQ, he mentions 'from Biology, last year' as a cue to students of the thematic system in which to formulate an acceptable SA. The strategy is successful in eliciting 'from plants?' as an SA. Mentioning *Biology* invokes a large, but in this discourse solely an implied thematic system, i.e. one whose meaning relations are not being constructed, even implicitly, in this discourse, except at the point where such mention is made (and there, obviously, only very weakly). That thematic system is immanent in some other discourses, which provide the relevant intertext. *Biology* is mentioned in a way that helps locate or identify the relevant discourses: 'last year' 'most of you' must have taken a school course in biology where these themes were discussed. Through the indicated system *Biology* the teacher develops thematic relations of the actually instanced system *sources of components that affect atmospheric heating*.

In DRS we have the similar use of 'General Science' (5L25), which helps identify a set of discourses, particularly when the teacher instances the thematic system within *General

Science* (also a school course) that he actually wishes to invoke (5L22-6L6). His later remark about 'Relativity!' and 'Einstein' (6L13) invokes a purely implied system, and through it, the relevant texts or discourses. More work needs to be done on the uses of intertextual devices in thematic development than was possible within the scope of this project.

4.0 Some Other Important Strategies

Discourse is metacommunicative in many ways. It may thematize its own interactional processes, develop an explicit thematic system for describing its own meaning relations, and 'comment' on itself explicitly and implicitly. Two such 'commenting' functions are particularly frequent and important in classroom discourse. One marks part of the discourse as Old (or New) Information, another marks part of the discourse as relatively Important (or Unimportant). In this section we will describe these two functions as strategies for thematic developmetn and control, and then add examples of two other, less common but rather interesting strategies: Framebreaking and Joint Construction.

4.1 Marking discourse as Old Information

A general functional system of the English clause is its resource for indicating what is to be regarded at the time as already 'given' or known information, and what as 'new' inforamtion. The ordinary, 'unmarked' structure simply puts the 'new' at the end of the clause and in clause sequences, intonation may mark 'old' and 'new'. The positional marking of 'old/new' is possibly a condensation of the unmarked marrative structure of English discourse: later clauses, even in the absence of other indications (e.g. conjunctions, tense markers), are taken to refer to later events. Obviously there are many narrative devices (marked structures) to shift the relative order of telling and happening. The well established 'fallacy' of 'post hoc ergo propter hoc', indicates that, where thamatically permissible, causal as well as temporal relations of events are taken to follow clause sequence 'automatically'.

In the classroom a very high percentage of information is 'new'--not just at the clause level, but in terms of student accountability: 'old' information should already be known by students; new information they are currently learning. Anything from a previous lesson is regarded as 'old', and during the course of a lesson (e.g. in EL below) information may have its status changed by teacher from 'new' to 'old'. The unmarked case is that information is new unless specifically marked as old. For purposes of thematic development, teachers need to constantly create ties between 'old' and 'new' information, and when this is done explicitly, teachers usually mark which information is 'old' in the process of, sometimes interextually, identifying it for students.

In the first episode of DRS, teacher begins with a meta (1L1): 'Before we get started...' which thematizes the interactional status of 'getting started', but the 'before' cataphorically marks the episode, retroactively bounded from (2L23) as Review and thus everything in it as 'old' unless specified as 'new'. There are two other metas in the episode, which also mark it as 'old': (2L18) which repeats 'before' and links it syntactically to 'notes' for whatever is in the students' notes is 'old' (and anything 'old' should be in their notes); and (2L22-3) which explicitly says 'review'.

The explicit marking strategies include direct reference to past lessons (usually 'yesterday'), and use of the term 'remember' as in EL (1L1-4), or the marking of 'old' to prepare for connection with new thematic development as in LG(2L24-6) where 'remember' is vocally emphasized and accompanied by past time, 'last week', the associated should, first as 'I expect you' and then as 'should be', and an explicit marking of 'easy' (vs. 'difficult')--another discourse marking strategy, but one which usually functions interactionally (to prompt SAs, or challenge student competence) rather than thematically--'a snap'. At LG (12L20-21), an intertextual instance, teacher marks 'old' by 'last year' (past time) and 'should remember' (expectation, memory). Still explicit, but now acting to convert 'old' to 'new' as well as mark it originally as 'old' is LG (6L14-16): 'remember back' 'eighth grade' 'you should've' and then the shift to 'new' thru 'we'll learn it now.' The same happens at (11L7-10): 'you didn't know' 'almost all do know' shifted to 'write it,' i.e. and learn it now. Note that in the example from EL (1L1-4), the 'missing' feature--expectation--

is supplied almost immediately thru teacher's implication that the student who interrupts him to ask for the pass should have been able to answer his old information' TQ.

Implicit means of marking 'old' can be quite subtle. At LG(10L11) we have only the past tense and the intertextual identifier ('Mr. Scott gave to you') as a comment on what student remembered in her SA, marking it as a remembering. At LG (9L5), the TA carries an intonation contour that makes 'What is the ground giving off?' equivalent to "Now what did we just say the ground is giving off?", at (8L12-14) and repeatedly since (4L24). In KF (1LL-17) teacher interrupts an SA (1L14) and when student resumes, there has been an unusual 'clausal' ellipsis. The 'also' (1L13) signals that the elided clause should repeat the preceding 'it's a free element'. In their joint deletion of this teacher and student mark this as not just redundant, since such repetition is usual in classroom discourse and essential to global thematic development as we have seen, but as discourse and essential to global thematic development as we have seen, but as 'old', as something it is expected everyone has already mastered. This episode of Going Over the Do Now is functioning as a Review, tho as we shall see in section 6, its thematic systems are still very much 'under development.' At KF (5L4-8) teacher poses a TQ, then answers it himself without pause, marking it as a rhetorical question, and its presupposed thematic system as 'old', as not part of the currently-being-learned material of the triad dialog, but part of teacher's summary monolog.

As a final example, consider EL(10L14-15) where teacher clearly marks the status of what was 'new' a few minutes ago (e.g. 6L5) as now being 'old', responding to an SA with 'you didn't listen to what we did before' asa TNegEval conflated with a TAdmonish, implying the student should have remembered the answer from 'before'. In fact, in this lesson what is required is a complex logical inference, for the thematic system is still incompletely constructed at this point, but nonetheless teacher treats the situation as if the status were 'old'. This is not the same as the situation at LG (9L5) where the thematics had been completely constructed previously. In EL, the student must generalize from the discussion of the spring, pivoting on the category 'longitudinal wave' to conclude (not remember) an SA. In this discourse of testing, not otherwise analyzed in this project, all thematics has the status 'old,' tho as in EL students may be expected to 'go beyond' what has been developed in class. These usages are good evidence that it is the thematic systems themselves, and their use, not the constitutive 'propositions', which teachers consider themselves to be teaching thru science classroom discourse.

4.2 Marking discourse as Important

Anything that is said in the classroom may be important: may be 'on the test', may be the subject of a later TQ, may contribute to the construction of a key meaning relation of a developing thematic system. Teachers mark some discourse as relatively Important and some-much-less-as relatively Un-Important. There are a variety of explicit and implicit ways of doing this which may serve as strategies of thematic control and thematic development.

Anything teacher *writes on the board* is marked thereby as Important, as is made quite clear by teacher in EL(2L27-3L3). *Repeating* statements, both brief teacher repeats of SAs and expecially repetition of teacher's own longer statements after some interval during the lesson. Teacher's also mark SAs as especially important by *strong* TPosEvals, as at LG (10L 17) '*Exactly!*'

The *most* explicit marker, i.e. directly saying what is or is not important, is relatively rare. It occurs in DRS (18L1,18L3-5) partly as an *interactional* control device in the first instance (cf. 17L30, a rare general admonition in DRS) to draw students attention, and with the locution thus 'on hand.' Teacher uses it in the negative to answer the SQ of (17L27-8). More common, and still explicit, are a variety of lexical emphasis markers such as 'the main question' (LG1L1), 'the key idea' (LG1L24), 'now notice' (EL3L7), 'essentially' (LG 3L12,13:5L10), 'the clue' (KF2L5), 'don't be tricked by' (KF 2L25), 'the point here' (KF3L9), 'the inner mechanism of this whole procedure' (KF 3L14), 'let's make note of' (KF4L24-5), etc. There is also the use of 'the Aim' to mark the most important and general theme of the lesson (cf. LF1L8, JR10L9).

Teachers may also construct 'ad hoc' markers of this kind and repeat them as with the'special name' in LG (e.g. at 7L14). In addition to lexical emphasis markers, ordinary vocal emphasis is also used to mark importance globally (LG8L12-15), though more often it is used only for more local emphasis.

Very frequent among the indirect markers are those that depend on writing or students' copying in their notes as signals of importance. For example, KF (6L11-12) 'so everyone can copy' and (5L30-6L1) 'writing down your words of wisdom' in a situation where a student, not the teacher, is dictating orally (not writing at the board) what is to be copied.

The teacher may add personal comments that mark discourse as important, as in DRS (17L2): 'Hmm. Interesting.' and (19L1): 'Isn't that amazing!' Or LG (12L5-6) where teacher's comment humorously exaggerates what a student can do with this important information, identifying 'it' in the clause-final 'new information' position as 'about heat retention'. One can also note that teacher self-corrections mark certain contrasts as important, e.g. teacher's 'wrong' to himself at DRS (17L16).

Devices for implicitly marking information as Unimportant, or more often simply as non-relevant-here are also worth notice. This is often achieved through deletion, as when (LG2L30-3L3) 'capsulizes' the SA 'sunlight' as just 'light', or in DRS (20L5-6) where teacher deletes '4f14', simplifying the final expression of a series and so making its similarity to the other members more prominent. DRS also uses an analogy to a lesson-specific prior instance of Unimportance to mark another distinction as being as unimportant (at 17L6-10) as that 'You say Iodayn, I say Iodeen'. EL (5L19) uses 'but in either case' to mark a student-question and his response as not important for the main issue. Nearly all these uses are thematic control devices, reacting to student thematic contributions.

4.3 Framebreaking and Joint Construction

We consider finally two quite different but interesting thematic development strategies. The first occurs in EL (3L17-6L5; 9L16-11L7) in the development of a system of thematic relations we can label as *the medium moves both ways*. We will not analyze here the entire thematic system of *longitudinal waves* to which the system of interest belongs, or even the many constitutive discourse strategies thru which it is developed, but one particular one we can call Frane breaking. In this strategy teacher is essentially altering an existing thematic system which conflicts with the one he is developing. The discourse breaks out of a limiting thematic frame in order to establish the new thematic relations. One expects to find this strategy when, as here, the new relations are 'counter-intuitive.'

Having reminded students thru a board diagram review of a demonstration done in class in which a compressional pulse traveled down a long coiled spring (3L4-16), teacher asks (3L17): 'Which way does the spring move?' At (3L7-8) teacher has just said 'Now notice that the spring does not move...' There the emphasis on 'spring' established a contrast with 'pulse' or 'wave' which 'does move', and here (in the TQ) it establishes a different contrast between these same two terms. The nominated student answers: 'the opposite', but other students object that 'it's not moving' at all. Another meaning contrast is needed to split the two contrasts which are still one for most students, and this is provided by 'wiggle', splitting *move* into *move from me to the door* (spring doesn't; pulse does) and *move: wiggle* (spring does). If teacher were more specific, or used available technical register distinctions, he would have answered his own TQ and pre-empted dialog responses. Teacher repeats the main question, a student answers 'the same way'., setting up a contrast system *same way/opposite way*, teacher ignores this, develops the new distinction a bit more as '(spring)/wave travel' (i.e. *'wiggle' vs. 'travel'*, and now the nominated student repeats his previous SA (which has not been evaluated yet) and teacher engages him in duolog to clarify what 'the opposite' means. Finally (4L2) there is a TPosEval, reduced to a T½PosEval (correct but incomplete) by 'Does it move in any other direction?' No responses. Since 'the same way' was offered before, and no answer is offered now, we assume that for students there is a limiting meaning relation system operating in which *same way/opposite way* are in *mutually exclusive* contrast. (There is plenty of student discourse evidence for this in later dialog.) Since 'the opposite' has been positively evaluated, no options remain. The system is a simple binary one, also representable as *(± same way)* or *(± opposite way)*. This is the student's frame, limiting the discourse, which teacher must break. He returns to the board diagram and initiates triad dialog, leading students to say that the spring moves to the left and then to say that it moves to the right. (4L30 and the thematically related dialog at 5L15-19 are still working on the *spring/pulse* contrast in this new context.) Teacher now poses the main question again (5L1-3), using the local equivalence of 'medium' and 'spring', and gets two answers: 'both ways' and 'toward the *middle*', the one 'conjoining' the other 'compromising'. There has thus been a shift from the simple binary system of alternatives. Minimally, there is now a ternary structure *same way/opposite way/other*, where the third alternative is realized by some students as 'toward the *middle*' and by others as 'both ways.' Teacher's structure is a *doubly* binary system *(± same way, ± opposite way)* with two *independent* alternative pairs, as revealed in his dialog strategy: '± *this* way?' and then also '± *another* way?' This may already be shared by some students. Teacher selects the SA 'both' in his summary statement (5L6-7) which he writes on the board, and repeats at (5L14) '*both ways*', and restates as 'parallel and *anti*-parallel,' 'same and opposite direction' (5L20-21), and 'to the right and to the left' (6L5).

At (9L16) teacher returns to this issue of the motion of the medium, which is now 'air' rather than the spring. Again the question is posed as 'which way'. Teacher specifies the wave ('sound') 'moves to the right', and all the student responses are singly directed and those that are in the 'right/left' system are 'to the left' or *the opposite way* The simple binary frame is still in place. Teacher invokes global thematic context of situation, *longitudinal waves*, which links this case to that of the spring, and for which (5L22-6L10) teacher formulated the 'right and left' alternative. There, however, he emphasized 'parallel' in preparation for a later contrast in the lesson with 'transverse waves,' and any answer in the 'right/left' system satisfies that criterion. Teacher restates the main question at (10L8-10) and now works thru a lot of negative evaluations and admonitions, marking this issue as 'old'. The students hold firmly to a mutually exclusive frame, and teacher even poses the question once, trickily, with interactional control as well as thematic development effects, as 'to the right or the left?' (10L19). Finally he nominates a 'reliable' student and gets 'both ways.' While in (3L17-6L5) teacher's frame breaking strategies were mainly constructive, adding alternatives or splitting *(A/B)* into *(±A, ±B), here they are mainly deconstructive, at times encouraging *(A/B* so that he can label it as inappropriate. Finally, he recapitulates the explanatory dialog of (4L3-5L7) in a monolog

(10L29-11L7) that ends with a double statement of the *both ways* theme, realized thru 'alternately', 'to the right and . . . back to the left', and 'two ways'. Much of the work of work of thematic development in the science classroom consists in 'clearing up misconceptions', often simply by marking student-initiated connections as 'wrong', or 'not relevent here,' but at times the conflicting thematic frames cannot simply be 'set aside,' they must be changed, and one expects that again it is long-term, global discourse processes, not brief explanations or single episodes, by which this is interactively accomplished.

It is also true that all global thematic development in these classroom discourses is interactive in character and thus a 'joint accomplishment' of teachers and students, and that, obviously in dialog, and globally over the whole discourse, the thematic relations tend to be constructed not just from teacher's utterances, but from students, and their relations. But there is also a specialized strategy of local thematic development, distinct from triad dialog and from T/S Debates, indeed a form of dialog which is not analyzable interactively in terms of 'responses', 'adjacency pairs', or other reciprocity models of dialog, and which we can call Joint Construction. What is jointly constructed is not simply the thematic relations, but very often the linguistic structures ('sentences' 'clauses' themselves. It is a crucially important general phenomenon of discourse that other participants frequently can and do complete a speaker's utterance in a way satisfactory to the speaker, often in situations where the speaker seemed 'unable to find the word.' This phenomenon is part of the evidence that discourse operates thru a shared system of meanings (and of wordings that discourse operates for those meanings) which constitutes discourse as a social phenomenon and not the mere juxtapositon of autonomous individual speakers utterances. In dialog we may go so far as to say that no speaker is the sole author even of his or her 'own' utterances insofar as both the wordings and the meanings of those utterances belong to and depend on the social construction of the entire discourse in which alone they have their meanings.

At LG (11L11-17) we find a 'side TQ': 'by the way, what is a cloud' inserted in the restatement of the 'main TQ' (11L10-11, resumed at 11L17-18). There is a 'chorus' answer from students, humorously admonished by teacher, restated and followed by a nomination. Erin begins her answer, 'It's water vapor and uh-', but teacher overlaps her speech with a strong TPosEval at the minimal pause following 'water'. One supposes that Erin would have gone on to say 'and uh- carbon dioxide' since these two items have been conjunctively linked many times in the preceeding discussion (10L24-11L7) and are so linked on the board. The 'chorus answers' were 'water, water vapor' (not a pure unison chorus), and teacher 'drowns out' Erin's word 'vapor' and continues her sentence, with her 'It's water' as its initiation, 'in droplet form, on little dust particles.'

Water in droplet form' contrasts in this context with 'water vapor', and 'carbon dioxide' would not have been acceptable. One could construe this dialog as normal triad with the sentence continuation as TElab, but the second function of the TPosEval as selecting a part of the wording as 'correct', and the second function of the TElab as a continuation of that wording, retroactively also selecting only 'It's water' and not 'vapor' (since 'vapor in droplet form' is not a well formed expression in this thematic system), would be obscured.

Teacher restates the main question, Erin bids and is renominated, answering 'It reflects it.' Teacher asks for clarification/elaboration ('What?', and Erin expands the first 'it' from the wording of the TQ, and the second from the preceding episode (10L15-22), using the word 'heat.' Teacher asks for further elaboration, and Erin now backtracks and changes her second 'it' to 'light', renewing the *heat/light* contrast whose acceptable use in different contexts has been the most contested meaning relation of the lesson between teacher and students (see section 6). She then goes on to respond to teacher's request: 'and they reflect the-'. But teacher again overlaps her speech, repeating her words and placing 'the heat' where she would presumably now have said 'light' again. Teacher structures his utterance as a repeat of his request, but it clearly also functions to jointly construct Erin's answer in acceptable way. She continues her answer, in effect answering teacher's second request question, 'back to the' and another student completes with 'ground', which she accepts and repeats. A full answer, amounting in all to one 'net' clause, has been jointly constructed by Erin, the teacher, and the other student.

In DRS (9L8-19), the teacher asks for an alternative, presumably 'in your own words' version of a read SA that had probably been copied from the textbook, and nominates Cheryl. Cheryl begins, teacher interrupts her with a comment that is said as if an appositional equivalent to what Cheryl has said thus far, but actually changes it (because in this thematic system 'at a lower energy' and 'no added energy' are not equivalent). The teacher signals to Cheryl to continue, which she does as if continuing an original compound sentence before the interruption, but precisely at the point where we expect a parallel to the previously 'corrected' 'at a lower energy' (such as 'at a higher energy'), teacher again interrupts and speaks as if completing her sentence, but builds a contrast on his previous interruption (*'no added/you add'*) and develops this in a narrative structure. Both thematic control and thematic development have been served by this strategy. The teacher pre-empts Cheryl's likely qualitative ordering relation *lower/higher* and develops a quantitative additive one *add/lose energy* (cf. 9L24-6) which is more central to this thematic system.

5.0 Student Use of Thematic Development and Central Strategies

All of the basic strategies of thematic development and control used by teachers are also available to students. What is not 'available' are the 'intertexts' thru which teachers maintain for themselves and can enact in current discourse with students the 'science' thematic systems. But the thematic systems teachers, or we, recognize as 'canonical', as the 'science' systems, overlap, especially in classroom discourse, with the thematic systems of meaning relations current in wider communities of discourse in which students also participate outside the science classroom. These may conflict with the 'science' systems, be less exclusive in their contrasts, or more inclusive in their equivalences, or simply draw different relations among, and differently categorize their 'themes'. The register of science classroom discourse is a hybrid of the register of technical 'scientific' discourse, 'school' discourse, and the 'common parlance' register, which is most widely shared in the large discourse community. Teachers tend to signal when they are speaking 'science', or at least to separate utterances in 'science' and in other registers in some way. We will discuss this issue further in the next chapter. But students do not necessarily 'know' what is allocable to a 'science' register or 'science' thematic system, and so the thematic systems they enact are such hybrids. Much of student contribution to thematic development is not constitutive of the 'science' system teacher is developing - hence the need for triad dialog and other mechanisms of teacher thematic control - but functions, globally, with teacher's discourse to delimit a separable domain of 'science' systems with definite relations to the non-science domains of discourse and their thematic systems.

Even in triad dialog, SAs may diverge from the thematics teacher is developing, especially if the TQ is 'open-ended', i.e. seems to have more than one possible answer. When in EL (6L23 seq.), teacher asks for 'an example' of a longitudinal wave, the answer 'a telephone call' leads to a long digression on electrical transmission. The linkage, in terms of teacher's example of the spring, and what the student may have heard about microwave transmission, phone calls via satelite, or other thematic links discoverable say by interviewing the student is probably well as thin the likely connections of widely shared systems of meaning. Teacher tends to construe the answer as mainly misconceived, but could as easily have noted the wave nature of much telephonic transmission as an example of 'transverse' waves, the next major theme of his lesson. At (8L4 seq.) teacher gets 'water waves' as an answer to this question, and the thematic mismatch problem is similar. When the TQ poses itself as having one definite right answer, one may find students trying to answer acceptably in a thematic system that does not have the distinctions and relations teacher is trying to develop. This is happening in EL (1L1-19), previously analyzed, where a student bridges over into the 'science' system with his query to teacher about which contrast set is applicable (1L16), a student use of a thematic meta.

Students' own questions frequently introduce new thematic connections, as in LG (7L22 seq.) when Charley makes the connection between 'heat that rises from the ground' (7L10) and something he's seen 'when you're driving down the street', seconded by the same theme in Rosie's 'like a little puddle.' As here SQs frequently ask in effect whether a connection they make thru the 'common' thematic system is a valid one in the 'science' system. But SQs also act within the 'science' system to obtain further development of particular linkages they know or suspect exist. In DRS (12L24 seq.), Cheryl asks about orbital sequence, an implicit theme since the start of the lesson, and then in succession two other students ask teacher to develop the sequence system beyond what he has done so far (14L4 seq., 14L17 seq.) In reply to the last of these teacher introduces a numerical relationship, *number of elements is twice the number of orbitals*, and a student asks afterwards (15L10) 'What was that thing with the n-squared?' This is thematically cohesive in that it asks about another numerical relationship involving the number of orbitals. Students need not maintain the etiquette of question form, as at DRS (19L3 seq.) where students simply exhort/demand 'Tell us about the B's!' in a humorous (interactional norm-violating) tone.

Students may also directly contribute to the system teacher is developing as Jeff does in DRS (18L14 seq.) when he describes the similarities teacher has been implicitly exhibiting in the previous triad dialog. In operating that system 'correctly' students may still diverge from the particular relation teacher wants to develop as in LG (10L4-6), where Vito introduces the 'correct' idea that clouds absorb radiated heat, when teacher is more interested in the fact that they also reflect it.

The devices students use to construct thematic relations are essentially the same as those used by teachers. Thus in KF (1L11-23) we find 'Na' contrasted with 'O_2' by their appearing in similar environments (1L12013), showing that 'Na' and 'O_2' are distinct members of a class of similar items ('elements'), and then (1L15-17) we get the same device used to contrast 'sodium' and 'oxygen' (environments: 'was plus one' 'is minus two'). There is also the implicit contrast of these latter two to the first two (via *'plus, minus, zero'*), and all four of these are in contrast with 'Na_2O' which does not have an 'oxidation number' but is a structure 'in' which other items have theirs (cf. *compound/element*). The relation is constructed in part by the preposition choices: 'for' elements with numbers (1L12,1L15), 'in' for the compound (1L15). We then find a contrast by emphasis and by self-correction jointly constructed by two students in the 'gained/lost' relation in (1L19-20). We also find a rather complex duality system (parallel, interdependent substitution contrasts, see section 6) being constructed by Andrea in KF (6L5-6 seq.) thru a systematic variation, repeating the structure of an earlier (global) teacher version (4L26-5L5, and within version on the board). In SC (2L3-11), teacher asks a yes/no question about finding a 'fossil', and Charley answers 'No, an impression yes' creating by emphasis and by induction from the *yes/no* contrast pair a second contrast *'fossil'/'impression'*, which was probably introduced by teacher in a previous lesson since this distinction belongs to the 'science' system rather than 'common parlance' (and 'impression' is lexically unlikely as a realization of this theme in students' 'spontaneous' register). Teacher then begins a follow-up TQ, and Charley's answer (1L9) retros the TQ to an ellipsis in the cohesion chain of 'fossils' (i.e. 'Why not a fossil?') and the emphasis on 'bones' contributes to the larger thematic system teacher completes with the equivalent 'hard parts' (2L10-11). At (2L30-3L3) Monica generalizes in a purely relational outline of the current thematics. The conventions of abstract discourse may be useful synthetically, but tend to be meaningless outside the context of the specific instances they unite - cf. teacher's request, just after for an 'example'. Teacher's question leaves the thematic context sufficiently 'wide-open' that students introduce themes with very different relations to *fossil displacements* than the ones teacher is developing ('glacier' at 3L11-14, 'dome' and 'intrusion' at 3L17-18). In an interesting role reversal, typical of some T/S Debates, at SC (5L17) a student renews a cohesion chain interaction (from 5L10 *proof/fact*) in response to teacher's 'something else' which *might* have been a signal of a thematic shift. Student is exercising, or at least bidding for, thematic control, trying to make sure teacher 'stays on the topic.'

Students' role in thematic control will be quite evident in Section 6 below, but we can note here a few additional examples. At the beginning of the Main Lesson in JR (1L1-22), teacher introduces a narrative line about a 'movie' with actor 'Steve McQueen' and as he begins to specify the relevant theme of this film, a student *overlaps* his speech and specifies (1L3-4) *another* theme (from a different, more recent film with the same actor), as if in *joint construction*, completing teacher's sentence. Teacher continues and the student's theme is not further developed. At (1L8) another student bids humorously to link teacher's themes to his own 'rival'. Then at (1L16-17) a student asks a question which links teacher's themes to a 'science' thematic system developed in a previous lesson. This time teacher *does* respond, ratifying the linkage. Then (1L21-2) one student, Mr. Y, first sarcastically makes a 'common parlance' link, and then 'complains' that teacher's narrative is not itself in a 'science' thematic system. This *meta* belongs to the 'science ideology' system we will be discussing in the next chapter. Another student continues the topic of (1L16-17), and then teacher himself continues as if that (student introduced) theme **'Blob' is one-celled animal*) were now acceptably integrated in the discourse (1L23-5).

Later in JR (4L5-23), Rita introduces the theme *organelles*. There is a duolog development with teacher in which student establishes a series of _equivalences_: 'the cells _inside_ the cells' by _glossing_ 'I mean' and _similar environments_ 'inside the cells' to '_parts_', and then, by a parallel construction, emphasis, and the same environment again, to _organs_. Later (4L14-16) in the duolog, these '_organs_' will 'crowd out the _other_ cells', _self-corrected_ to 'the other _organs_'. Here we have local equivalences (*cell, part, organ*) reflecting the 'common parlance' system's lack of relevant distinctions, hybridized with the 'science' system's contrastive use of *cell/organ*. Teacher supplies the technical register term 'organelles' in a contrast 'organs or organelles?' (4L18-19) to help her solve her wording problem. She has built her discourse without such a word, but _with_ the appropriate system relations; i.e. spoken of something '_parts_ inside the cell' like organs, but not 'cells'. This student-introduced theme, and the thematics of her global argument (see section 6), continue in the lesson, with the teacher using *organelle* at 18L6, 9L13, etc. Though students do not use 'organelles', they do continue the _theme_, realizing *organelles* by common parlance locutions such as 'the little stuff that's in there' (8L2-3). Rita's preference for 'organ' as the most frequent term for this 'something' may be built on the sound similarity to the technical term, or -- as the morphology of 'organelle' itself is -- on the functional analogy of these two levels in the hierarchy of biological structures. (Organelle is to cell as organ is to body, or organism.)

A genuine use of analogy in thematic development by a student occurs at JR (8L30-9L1, 9L8-11), where we find 'like with a person... So that the cell-' interrupted by another student who bids to end this discussion and get back to an earlier theme, but the teacher lets the analogy maker continue (9L8) and he repeats 'Like with a person... So with a cell...' building a formally 'perfect' parallel-construction analogy realizing the thematic relation: *object (person/cell) growth implies proportional growth of its internal parts (organs/organelles)*, which students have been trying to construct an acceptable 'science system' realization of since (2L2).

Student contribution to thematic development will be further illustrated in the episodes analyzed in the next, concluding section of this chapter.

6.0 Thematic Strategies in Operation: Analysis of Episodes

Let's look once again at the opening episode of DRS. The 'science system' themes begin at (1L16), where the cohesion chains of *(board) diagram*, *representation*, and *Term Symbols/orbitals* begin. At (1L18) the TQ establishes that *elements* as well as orbitals are representable (modal: 'could') by *diagram*. In (1L21-3), we have realizations of the thematic relations of *electrons* to this system. Then the *Term Symbols/orbitals* system is developed in relation to *(board) diagram*, and finally all these themes are brought together in the nexus TQ (2L5-8). In that TQ an important contrast feature is developed in relation to (1L18). The plural 'elements' has become singular, the modal 'could be' is replaced by 'is being', and 'such a' becomes 'this' while 'diagram' has become 'configuration'. We thus have systematic contrast across these parallel syntactic constructions in the two locutions. The *(board) diagram* theme has been split so that a contrast *orbital diagram/electron configuration (diagram)* can be linked to the corresponding contrast *represents more than one/just one element*. 'Configuration' is equivalent to the theme of (2L5-7), i.e. *a definite number of electrons specified for each orbital*. While there are many thematic relations being developed in this episode, I want to focus now just on the dialog that follows this nexus TQ.

Teacher nominates Ron, a 'bright' student who would be likely to give an acceptable answer to this long and thematically complex question. Ron's intonation in his SA 'Boron?' indicates his uncertainty and the teacher does not give a positive evaluation. 'Boron' is cohesive with the theme chain *elements, hydrogen, helium*, by the ellipsis that reduces an implied full statement answer to his single word (e.g. 'The element is Boron'), and by the intertextual system in which 'Boron' gets used, like 'hydrogen', as 'one of the chemical elements'. Note that names of specific elements (hyponyms of 'element' in *elements*) figure in SAs, but not in TQs in this episode, and not in the nexus TQ. This pattern helps to mark them as Unimportant globally. Indeed none of them appear again in any new thematic context in the lesson, although the *chain*, including still other element names, *spans* the lesson text (from 1L18 to 20L30), a common feature that helps make this discourse 'chemistry'.

Teacher's response to Ron begins with a self-correction; the initial locution 'that would be' is normally followed by an element name when an electron description has been given, but a name *is* what Ron has given, so the teacher shifts to 'that'd have' which is normally followed by a locution of the number of electrons in some orbitals, as in (1L21-3, 2L5-7). This is followed by a number, '*seven*', with contrastive emphasis, and electrons', but then a cataphoric equivalence is built with 'so you'd have to have' between the '*seven* electrons' and the series of phrases that follow, which are of the expected pattern *number of electrons in each orbital* realized as 'one here..one here..' with the orbitals 'pointed to' on the board diagram, and 'electron' deleted each time.

A lot is happening here. With *what* is '*seven*' in contrast? What is the meaning of the equivalence relation then built? By what *thematic* relations is teacher's response, and presumably the cohesion by substitution of his 'that/that'd' linked with Ron's 'Boron'? Note also the *modal* shift: The TQ had shifted 'could' to 'is' (above), but in the framework of a conditional ('If I have..., what element is...'). Now teacher's subjunctives ('would be', 'that'd have', 'so you'd have to') reinstate the conditional as in fact a *counterfactual*: i.e. 'If it represented Boron, there would have to be...' and teacher is in the process of building a *reductio* strategy to demonstrate that there are *not* '*seven* electrons/one here...' in the configuration diagram. The *equivalence* relates 'one here... one here...' to '*seven* electrons', and they are equivalent in the sense that '*seven*' is the *total number* of electrons in all the orbitals. (2L11) establishes a thematic tie *element-total number of electrons* which did *not* appear in the prior discourse. In *these* terms '*seven*' is in contrast with the *total number* in the TQ (2L5-7), which is *six*. Teacher's response is cohesive to 'Boron' only thru the thematic relation *element-total number of electrons* realized here as in effect *Boron has *seven* electrons*. Teacher is continuing his 'one here' series when *another* student calls out 'Carbon' and teacher seizes on this to establish 'Carbon' as the right answer. 'Carbon' has (a total of *six* electrons. Globally, from (2L5) to (2L16) there has been a transition from the foregrounding of the relation *element-electron configuration* in the TQ to *element-total number of electrons* in the actual answer strategy. Students didn't need to know anything of the thematic system of *orbitals* so prominent in the TQ in order to answer it; they only needed to count up to the total *six* and look at their external text (a Periodic Table, cf. teachers' 'here' in 2L15) to answer 'Carbon.' The TQ created a thematic nexus, but the task it posed could be solved by the 'short-cut' of counting. (In case it bothers any reader, not only Ron, but also teacher made 'anomalous' thematic connections: Boron has neither six nor seven electrons as a neutral element, but only five.)

This brief DRS episode is quite rich in examples of the complexity of thematic development thru discourse, and of how much of the relations constructed in it remain implicit, conveyed thru intonation, syntax, cohesion, and intertextual ties. But every discourse episode is like this. Consider next the development of the thematic contextualizations of the *light/heat* contrast in LG. We will focus on teacher's debate with Erin (5L17-6L23), after first reviewing the *light/heat* thematics that precede it in the lesson.

First (LG2L27-3L11), teacher establishes 'lightenergy' as 'radiant energy from the sun', selecting it and promoting it among its rivals from 'common parlance': 'sunlight' and 'solar energy'. But then a student offers 'Heat' as an answer (3L5), and teacher proceeds to establish a contrast between 'light' and 'heat' from the sun (3L6-11), marking 'lightenergy' again as 'important' (3L11). Note the similar environments device ('...from the sun') and the explicit 'compared to' as well as contrastive emphasis.

Next (LG 4L19-5L19), we have the immediate discourse context for the Debate. In dialog teacher establishes *earth absorbs light/ground gets hot*. He then (5L10seq.) asks 'But essentally, we're talking about what kind of energy now?' The identification of a 'kind of energy' is cohesive with the TQ of (2L27), the 'kinds' being only those of that episode. 'Essentially' was there the marker by which teacher promoted the importance of 'lightenergy' (3L2,3L11). In response to the TQ, students provide answers of: 'light' 'heat' and 'solar energy'. Without a strongly contrastive 'now' in the TQ, there is no way to anticipate which of the first two themes teacher is developing here, and it is only with the TPosEval of Rosie's nominated SA 'heat energy' that we know. Teacher completes this development with 'the ground is now creating heat energy from the light energy.' The 'now' clarifies the 'scene shift' from the earlier episode, co-ordinate with the shift from 'light energy essentially' to 'heat energy.' Ground is also emphasized, not obviously contrastively, but certainly as a marker of Importance, since teacher is leading up to (actually back to) the main theme of 'terrestrial radiation.' But in relation to (2L3-20) we can hear 'ground' in contrast with *sun*. And here is the basis of the SQ that initiates the debate proper: teacher has said *ground creates heat energy*, but what about the sun?

Erin's question (2L20-22) is a challenge. She asserts *sun creates heat energy* and sees this as incompatible with teacher's *ground creates heat energy*, invoking the *sun/ground* contrast, as an exclusive one. Teacher uses the common Concessive/Adversative strategy in response. Yes *sun creates heat*, but *in/on the sun*; the energy we get is 'light'. Two contrasts needed to split the 'common parlance' relations in use by students are not realized in his reply. There is no *on the earth* to contrast with *on the sun* as contexts in which heat is created, and no *ground creates* to balance the concession 'sun is creating' heat.

Erin asserts an explicit equivalence which would nullify teacher's distinction *heat/light*, namely *light is hot, is heat*. Teacher proceeds to a counterexample (fluoresent light not hot*, but Erin and another student challenge this with 'the bulb gets hot'. If the students' thematics prevails, the system of relations teacher is developing will collapse, and he resorts to 'essentially' and asserts the theme of his initial response (5L23-26) again. But as we noted that response was thematically incomplete. Erin now constructs another argument, hybridizing a 'science' thematic relation already ratified by teacher (in dialog 4L4-12): *darker surfaces absorb more* with her *light=heat* equivalence, to conclude that the ground is not hot because it is creating heat, but because it is absorbing the heat of the sunlight, in effect offering a new contrast relation: *create energy/absorb energy*, again as an exclusive contrast. I strongly suspect that a first reading of (6L6-10), especially by someone used to the 'science' system, would not find in it a cogent logical argument, as I myself did not at first. It is terms of the explication of the competing systems of meaning relations that this discourse appears 'logical' or not. Many patterns of natural discourse will appear logically valid or not, i.e. assimilable to a recognized formally valid pattern, depending on the thematic system of meaning relations in terms of which its discourse relations are construed.

Teacher responds by denying her equivalence in a contrast locution that asserts *A is not B, A is A*. Erin is a bit contemptuous of this, mocking it with *B is B*. Teacher now reports to an 'authoritative principle' (6L14-22), marking it as Old and emphasizing that students 'should' know this - in effect foregrounding teacherly authority to buttress his argument, the 'rule' is that 'you can change energy from one form to another' and teacher applies it here to *ground creates heat energy from the light energy*. He achieves an interactional and then a thematic boundary here, in effect getting the last word in this debate. In terms of the thematic system the new theme of *change forms of energy* makes a linkage that completes his argument and undermines the exclusive contrast of *ground absorbs/ground creates*, making possible *ground absorbs light/ground changes light to heat, creating heat from light*. But these connections are only implied, realized not even implicitly in this discourse, but only in some interest that develops more of this 'science' thematic system. Students can and do learn from implicit discourse relations, but not from invoked or merely implied thematic systems immanent in intertexts teacher has participated in but they have not, the discourse of the 'eighth grade' notwithstanding.

Our remaining two analyses deal with much more complex thematic systems and their development, which we will only be able to sketch here, tho these overviews are based on far more detailed word-by-word' local and global analyses. We look next at the thematic contextualization of 'the agents' in KF. The lesson began with a Do Now: two chemical equations to be 'balanced,' written as 'half-reactions' and analyzed in the thematic system of *oxidation/reduction*. Two students have written solutions to these problems on the board and the first, prompted by teacher, has 'explained his work'. In the dialog thus far, most of the thematic development has been devoted to his procedures and 'reasons' for these in balancing the reaction $Na+O_2 \rightarrow Na_2O$ (original unbalanced form). That system overlaps with the one we are focusing on in two ways: thru *oxidation/reduction* and thru *gain/lose electrons*. At KF (1L19-23) the correction establishes the relevance of *gain/lose* to 'calling' a reaction 'the oxidation half-reaction.' Disagreements about *gain/lose* run thru-out the episode, and their use in similar environments also maintain this contrast relation. Though only the term 'oxidation' occurs in the text (up to 3L20), 'reduction' as a contrast partner in a similar environment is on the board.

At (3L19) there is a thematic shift bid by a student, enforcing the XTXT (i.e. the Do Now instructions on the board) agenda on teacher, and introducing *oxidation/reduction agents* in contrast. Teacher approves this move, marks the thematics as New, and identifies a relevant intertext (the homework.) Teacher now foregrounds 'agents' on its own, and a student responds by making a syntactic tie *oxidizing agent is (named) element*, with appositional equivalence for 'O_2' and 'oxygen', but with only one instance of this in the discourse, the realization: 'The oxidizing agent isO_2, oxygen,' there is no basis yet for contextualizing the class realized as 'oxygen'. I have anticipated this by writing *(named) element*. Can any element be 'the oxidizing agent'? Is 'oxygen' perhaps the (only) 'oxidizing agent'? Teacher has on the board another reaction, actually discussed 8 minutes later, where the oxidizing agent is identified as chlorine, but teacher does not proceed by induction. He asks 'Why' oxygen is the correct answer, saying 'It makes sense from an English point of view, but...'. 'English' carries contrastive emphasis (also signalled by 'but') - with what? with *Chemistry point of view* we may suppose, but we can also hear in teacher's expression 'English' what we might call the linguistic (and particularly morphological) 'point of view.' There is a shared morpheme in: 'oxygen', 'oxide' (2L27,3L1), 'oxidation', but that is irrelevant (Unimportant) in the Chemistry thematic system in use here, which diverges from 'common parlance' expectations. A student now makes the key thematic link (4L2-5): *oxidizing agent 'makes the other' element 'become oxidized'* and at the same time invokes an equivalence (cf. 1L19-23) of 'give up' and 'become oxidized' where 'give up' realizes 'lose electrons' in *gain/lose*.

Students now construct two other thematic relations into which 'oxidizing agent' enters (4L7-8, 14,15), and which teacher accepts in each case as valid observations, 'but' (4L11,17) marks as less important than the first SA. (4L7-8) constructs *oxidizing agent gains ('adding to it' 'plus' electrons*. Teacher's response establishes an equivalence, by substitutive cohesion ('that's'): *gains electrons = 'reduction'*. The union of these new relations is explicitly constructed by the next student (4L14-15): *oxidizing agent is reduced*, who offers its universality ('always') as an identifying criterion ('the one') in response to the main TQ (3L30-4L1): 'How do you spot the agent?' But in the global thematics, we will shortly see, there is a duality between 'oxidation' and 'reduction' locutions that would be uselessly circular if the third students criterion, which lacks a link to *gain/lose*, were adopted. Teacher goes back now to the first students thematic link (4L2-5) and supports it by generalization thru a series 'any other agent: the insurance agent, the demolition agent, the CIA agent' taken in fact from 'common parlance.' The student comment at (4L21) marks the departure from the 'science' system. We now get the explicit generalization ('therefore...material or person...') and the specific instance of it in this reaction (4L23-4), as the monolog shifts into TSumm with a meta (4L24-5) while teacher writes at the board and paraphrases the written version. Note the local equivalence of 'allow' and 'enable' (and also 'make' from 4L3) by restatement (4L28), repetition and variation, etc. We will return to this elaborate thematic nexus (4L26-5L8) shortly, but note that there is a very indirect tie, of equivalence, between 'It goes down an oxidation step, (5L7-8) and 'itself is getting reduced' (4L17).

At (5L9) teacher shifts the thematic situation by introducing 'the reducing agent', with obvious contrast emphasis. He gets an acceptable answer and asks why ('Because?'). We now get in (5L11-20) a reenactment of the set of alternative thematic relations proposed by students as criterial for the oxidizing agent (4L2-15): first 'gaining electrons-, then 'being oxidized' and finally the acceptable 'enabling the oxygen to be reduced.' Teacher accepts the first as valid 'but', tho in the global system built here (cf. 5L21-7) below), it should be 'losing electrons'. The second is labeled 'true, but' and teacher now emphasizes (no contrast) 'call' to foreground the relation of the name 'agent' to the definition, recalling the 'call' argument of (4L17-20) in 'common parlance', as he emphasized 'agent' with 'call' in his previous response (5L14-15). This thematic development is completed in (5L21-27) by establishing the corresponding equivalence to (4L4, 5L1-3): *reducing agent loses electrons*. If we compare the 'reducing agent' discourse with the 'oxidizing agent' discourse that precedes it, we find a theme-by-theme transformation that constitutes a system of *dual* relationships. Every 'canonical' statement in one can be transformed into an acceptable statement in the other by substitutions of the *contrasting* thematic items in the pairs: *oxidation/reduction* and *gain/lose* everywhere one of these occurs. The *nexus* task is assigned to a student, who has only to operate this transformation to succeed. The model is on the board, written by teacher during the last *nexus* Summary (4L26-5L8). The student version fits this duality system (6L5-10) except for the unnecessary nominalization ('*reducing*' to 'reduction') and the difficulty of applying the *gain/lose* transformation to teacher's '*removing*' (5L5 and board) which there realizes *gain* (cf. 5L1). Another student corrects her (6L6), but this is not responded to. When she repeats her statement, many students object to 'gaining' (6L20) and teacher corrects it to 'losing'. In doing this he has noted an ambiguity in the interpretation of 'the sentence'. She repeats again and now several students, who had already heard and written ('gaining') object to her new 'losing' (7L2-4). The class is taking oral dictation' from this student and its attention is distracted from the dialog with teacher. Teacher repeats his argument that they should say 'losing', but now (7L9-10) another student demonstrates teacher's barely noted point about syntactic ambiguity by giving an explicit argument that 'gaining' is correct. She constructs a fully acceptable sentence within this thematic system, emphasizing '*enables*', teacher's own word choice, which shifts thematic focus from the 'agent' as *subject* (the 'actor' function) - cf. teacher's emphasis on '*itself*' in (6L22, cf. 7L6) - to 'enables' as *process*, the process being that of the 'reduction half-reactions' *in which* electrons are *gained*. Teacher concedes, the dictating student repeats again with 'gaining', and die-hards object again (7L18), but teacher goes on to discuss the next reaction. The syntactic ambiguity lies in the identification of a 'deep subject' for 'gaining/losing electrons.' If it is the *agent*, say 'losing'; if the 'reduction half-reactions', 'gaining'. But both the niceties of the register (*elements* gain or lose electrons *in* reactions, reactions do not gain or lose electrons), and the global transformation of the dual system of thematic relations, are more consistently constructed here with 'losing'.

This episode well illustrates that even explicit explanations of thematic relations have meaning only thru the *global* systems that are constructed thruout the discourse. The transformation of the duality system will be constituted globally despite local anomalies, just as those of language syntax are for a child despite the surface irregularities in what it hears and says, lest anyone think this observation a license for careless thematic development, we should note that students spend far less time hearing and especially actively using the thematic systems of science than they do those implicit in their mother tongue, and they have to accommodate 'science' systems to a 'common parlance' thematics that may offer as much 'resistance' to change as the phonological or syntactic features of one's original dialect in learning another dialect of the same language.

Our final episode for analysis constructs the thematics of *scaling* in JR (7L13-9L14). The Main Lesson thus far has dealt with the 'problems' of a 'huge cell' first directly, then thru the 'crowd analogy' we have discussed earlier in this chapter. At (7L5) teacher begins a summary of their results on the 'crowd's' problems and establishes the thematic link back to the cell (7L9-10), then he applies one theme of the analogy to the cell: 'Food can only enter along the outside edge,' of the cell, as of the crowd. From the analogy, this becomes a fatal problem for a very large cell, which cannot get enough 'food' to its central nucleus (cf. 7L17-21). But Mr.Y, anticipating the rest of teacher's argument, objects in an SChall (7L13-14) that begins a Debate: *bigger cell-more food enters* so why would food limit cell size? Teacher responds by conceding that more food would get in, and his adversative 'but...' is completed for him by another student (Joint Construction). This response however does not use the same thematic relations posed in the objection. It's underlying contrast is *food entry/food transport*, while that of the objection is quite different. Another student tries to restate the objection (7L22-3, 25-6, 8L2-4) and a comparison of the versions shows the thematic development. All these versions presuppose Mr. Y's original 'So...if it's bigger,...' and like his follow with a correlated comparative: 'more (7L13), 'bigger' (7L23), 'more ... bigger' (7L25-6), 'bigger' (8L3). The common form is: *If the cell is bigger, there will also be more/ bigger' 'X'*. In (7L25) we already have the term 'proportion,' used in an irregular syntactic construction, and at (8L5) we get the theme most recognizably; 'They'd be to scale'. 'They' here is the 'staff in the center', nucleus and other organelles, that need the food. The students' constructing the theme of *proportional scaling* to argue that cell size should be irrelevant, tho this second link is only implicit in the debate, i.e. in the utterancers' status as objections to teacher's argument. Teacher responds at (8L3-4) by noting that making these organelles 'bigger' is not feasible, but the thematic element that replaces the 'X' in the common form above is not crucial to the scaling thesis. Teacher responded to X='food', and now to X='organelles' but not to the structure of the students' arguments, i.e. to *scaling*. Finally Mr. Y tries again (8L11-16) and simply repeats the structure, using only the very general 'outside/inside' theme and then no 'X' item at all. Here is his version, thematically condensed: *If the outside grows, the inside grows (proportionally). If the cell doubles its size, 'it' would just double too.* This final, quantitative version leads teacher to begin operating with the thematics of scaling per se. He appeals to an authoritative principle' from 'Geometry' and indirectly contradict's Mr. Y's *If size doubles, everything doubles* by noting that 'volume' would grow 'a lot faster' than 'surface area'. He is trying to link this back to the cell with 'a greater proportion' - in implicit contrast with 'an equal proportion' in the students' system. But he is interrupted by the same thematic objection (8L27-30) from several quarters. His argument from geometry did not make some key thematic connections, nor explicitly contrast *equal/greater than proportional change.* The new objections pick up Mr. Y's successful 'inside/outside' theme, and one student adds an analogy to human growth (8L30-9L1, 9L8-11), realizing the theme of *equal proportion* as 'grow big to compensate for the size', but the 'X' in this version is the size of human organs (which do grow) in analogy with the size of cell organelles (which don't.) Teacher responds again to the 'X' element, contradicting the conclusion of the analogy (9L12-14), and the student's rejoinder is to challenge teacher's evidence for the constant size of organelles. The *scaling* themes are left behind, and teacher cuts off the duolog debate at (9L26-7) and moves into a TSumm monolog. Interestingly, he begins to enact the 'common form' himself (9L30): 'as the cell gets larger and larger and larger, the proportions in -' and then shifts definitively away, repudiating 'proportions' for 'the living material in' and continues his monolog on other themes. Teacher's strategies of thematic control in this debate, except for the appeal to 'geometry', have led to the thematic prominence of the 'X' themes, which fit more directly with the concrete, specifically cytological themes of his answer to 'why is the cell size limited' and away from the abstract, geometric systems in which other answers might be given. But this control strategy in the Debate operated at cross-purposes to a joint thematic development with students, whose key thematic relations required further development of the 'geometry' system to extend their 'common parlance' notions of *equal proportion* to include other *scaling* relations appropriate in the 'science' system.

CHAPTER FOUR: SCIENCE CLASSROOM DISCOURSE NORMS AND IDEOLOGIES

1.0 Discourse Norms and Norm-violations

In Chapter 2 (esp. section 2.2) we noted an important pattern in the 'cycle of violations and admonitions' by which science classroom (interactional) behavior norms are maintained as being 'normative' while constantly being violated (e.g. by student side-conversations). This pattern enables an ideology of 'individual learning' to be maintained while permitting in practice that social interaction between students which enables learning as a social process to occur effectively. We look now at the maintenance of discourse norms and find a rather similar pattern in which teacher and students 'hypocritically' maintain as normative certain ways of talking about science while their regular violations of these norms contribute in important ways to effective global thematic development. Such contradictions, from the analyst's point of view, are made possible by a system of disjunctions of meaning connections that sustain social ideologies about science and science learning.

In the first part of the chapter we will be concerned with explicating some of the discourse norms by looking at how participants react to their violation -- as we did with the behavioral norms and admonitions in Chapter 2 -- and also with analyzing the functions of the norms and of the violations. In the second part we will look more generally at evidence in science classroom discourse of participants' attitudes to the 'nature of science' and to science teaching and learning that function as parts of wider social ideologies.

1.1 Student norm-enforcement: explicit reactions

In sharp contrast to the enforcement of behavioral norms, discourse norms seem to be only rarely enforced on students by teachers, and are more often enforced on teachers by their students. This reflects the important difference that while teachers expect students to know how to 'behave' in class, they do not usually expect them to know how to 'speak properly' about science. I suspect that in the past, and probably today in some schools, one might find teachers who insisted not merely on 'correct pronunciation' (as at EL 12L3-10), using the 'right word' (cf. JR 4L18-19), 'good grammar' (LG 10L28-11L3), and 'staying on the topic' (as with thematic control strategies generally, see Chapter #3), but also on a certain 'textbook' or 'recitation' style in students' science discourse, moreso than did those teachers observed in this project.

Certainly many students have 'internalized' such discourse norms and, expecting teachers to conform to them in their science discourse, act to 'enforce' the norms on the teachers. Because of the sharp power differences in the classroom, at least when students ratify the usual power relationship, students do not so much 'force' teachers to conform in their discourse styles, by threats or by labeling their violations as such (the way teachers do when students break behavioral norms), but instead register reactions which serve to *publicly* note that a violation has occurred and which teachers usually do not fail to notice, though they may avoid giving a direct response. It is very likely that in this, as in many other domains, students' expectations set limits on 'acceptable' teacher behavior, at least in the short term. Students' *reactions* provide the analyst with clues to help identify the *violated* discourse norms of the science classroom. These reactions may be quite explicit, as we shall see, or they may take more implicit forms, such as laughter, discussed below.

The explicit reactions can help us to identify what specifically teacher has said that is taken to be a norm-violation. The reality of science discourse norms for students is illustrated by the reaction at JR (1L22), where Mr. Y -- who is something of a classroom 'leader' -- complains, 'Why can't he explain science in a scientific way!' Note the contrastive stress on 'science': There is presumably a non-science domain where the complaint would not be applicable, but there is 'a scientific way' to 'explain' science. This statement is made just after another student has introduced the first 'science' theme of the Main Lesson (1L16-17), linking it to teachers narrative account of a science fiction movie about a giant 'Blob'. That thematic bid also counts as norm-enforcement, as setting the discourse back to 'science' where it belongs; as do the implicit reactions of laughter and sarcastic comment with which students have accompanied the narrative (see section 1.2). It is presumably the whole 'non-science' thematics of the narrative that Mr. Y reacts to. But what constitutes a 'scientific way' of 'explaining science'? The answer requires a specification of the discourse norms of an 'ideal register' that exists in none of the lessons studied here.

Teachers do occasionally seem to enforce or foreground such norms. Thus at LG (13L30) teacher playfully rules 'out of order' potential reference to 'the movie' when discussing 'airports.' Fictional movies are in contrast with 'science' even if (especially if?) they share the same Common Parlance themes. At DRS (19L27) teacher repeats a student's highly elliptic 'one left in each,' asking 'What does that mean?' It must certainly be clear to teacher what it means in the thematic context; he is calling for a more explicit, less elliptical, 'full proposition' mode of statement. We find the same at LG (11L20) where a student's 'it reflects it' is met by teacher's 'what', asking student to say fully what reflects what. When a student does sound like a science textbook, a rare event (here the student reads a probably copied statement from his homework paper), teacher both asks him if he understands what he's saying and asks if anyone else can say it 'differently.' (DRS 9L8-9). Based on our previous analysis of the repetition and variation between teacher and student formulations (esp. JR 7L5-11L9), it seems that students usually avoid sounding like textbooks themselves at the same time they expect teachers' science discourse to be more regular. Thus students use personal pronouns, colloquial syntactic structures, 'informal' markers, and colloquial substitutes for technical or written register lexical items. When students speak 'written register' teachers may doubt they 'understand what they're saying'. In any case something in the 'textbook/student colloquial' register contrast is relevant to the discourse norms we are trying to identify.

In DRS (6L16-7L5) teacher and students are trying to describe a shape that has no common name (see section 1.2 for further analysis). At (6L23) teacher has described it as 'kind of a skinny eight (8)'. Another offers a different visual analogy: the 'infinity' symbol (∞), and then another student says 'you don't have a name for it?'. This comment, said with mild surprise, classifies teacher's descriptions as 'not names', i.e. not the expected technical terminology of the 'science' register. In elaborating (7L1), teacher says 'It's fat. It's uh...fat and skinny'. This follows the introduction by the previous student of the theme of 'three-dimensionality,' here colloquially realized. Now yet another student says 'That's nice and scientific?' She repeats this comment and teacher acknowledges it by agreeing. 'That' is clearly the use of the colloquial 'fat and skinny' in lieu of either a genuine technical term (there is none in general scientific usage) or the seemingly more 'scientific' image of a 'three-dimensional' 'infinity' symbol.

Later at (13L30), a student comments 'Mother Nature, right?' Teacher has just said 'if it was put together by nature...it would go this way,' where we have two linked contrasts: 'by nature' equivalent to 'by a chemist' and contrasted with 'by a printer', and 'this way' contrasts two ways of writing out the electron configuration of an atom. The student's reaction identifies this use of 'nature' as a violation of the norm against personification of nature, here placed in the same role with two human agents (printer, chemist). Looking back to 'fat and skinny' we note that these are not just colloquial, they are also human attributes in their primary usage. The 'unspecialized' colloquial register of 'informal' everyday intercourse among people who are not strangers is specialized for use in ordinary human social events, and tends, I suspect, to deal with other matters through 'human' metaphors and locations. The 'science register' on the other hand is comparatively 'un-human' in its ways of speaking.

At (17L31) a student comments, 'Oh we do?' sarcastically to teacher's 'We write them in pairs.' Teacher here is colloquially using the personal form 'we,' when the 'solidary we' of usual classroom usage means 'you the students and I the teacher, too.' Here 'we' obviously means 'I and others expert in these matters' and is actually contrastive against the 'inexpert' students. The non-human form, acceptable in the 'science register' might be: 'They are written in pairs.' Compare teacher's own (18L2): 'They're in pairs,' but he continues 'because they like to have these opposite spins.' The reaction is swift: 'They like to? (18L4) with its contrast on the lexical choice of a 'human' verb, where 'science register' might use 'tend to' or just 'are paired with opposite spins.'

In KF (4L19) a student calls out 'more, more, more!' when teacher has just likened an oxidation 'agent' to an 'insurance agent' and a 'CIA agent'. The student is publicly registering that teacher's discourse is unusual in a way that he finds amusing, and the location plays on a theme of classroom interaction, that teachers want to 'keep to the subject' and students want to 'get off' it. Thus this student 'encourages' in an ironic way that teacher continue discourse that is 'not science.' As with the 'movie' examples before, the norms link discourse thematics (topics that are or not 'science') and choice of 'wording' (colloquial or not; 'human' or not).

In LG (6L13) a student, in Debate mocks teacher's 'Light is light energy,' with 'yeah, and heat is heat energy.' In the context of the debate, already analyzed, the student is registering that teacher's locution is 'empty,' a tautology. As such it is banned from the 'science' register of 'full propositions.' In fact, in its thematic context, it is not empty, but it has the form of a norm-violation. Something similar happens later in (8L24-7), though here what is mocked is the convention of the 'science' register for 'universal' statements ('anywhere'). And in (13L12-15) when teacher 'fogs' a bit of the blackboard and refers to 'my breath' and its components, a student comment adds a component (presumably one of 'bad breath') that evokes considerable laughter from other students. The comment itself foregrounds the personal, human feature in teacher's discourse, and the laughter marks the 'unusual,' taboo, 'not science' character of the student comment. With the guidance of explicit reactions we can look more carefully at other implicit reactions that signal when discourse is abnormal. Then we will consider some generalizations.

1.2 Implicit markers of norm-violating discourse.

Consider again the very beginning of the Main Lesson in JR (1L1-22). Teacher's mention of a 'movie' and movie actor leads to a joking attempt by students to anticipate this 'non-science' theme. This would rarely happen with a 'science' theme. Then, at the first mention of 'The Blob' students make vocalizations registering surprise and mock appreciation. A theme of television movies is followed by Mr. Y's "Scott" and laughter at this effort to link the Blob to his rival. When teacher mimes the small initial size of the Blob (1L11), a student drawls 'Naw,' as if in appreciation of how 'cute' it must have been -- as with a baby or baby animal. In addition to the theme-shift by a student back to 'science' (1L16-17) and his disgust at all this 'non-science,' Mr. Y likens the Blob to 'condensed soup' -- rather than to a one-celled animal, emphasizing its thematic affinity to the 'non-science' realm.

Later when teacher develops the analogy of the big cell to the big crowd, there is a terrific reaction (6L1-14) to the student answer 'People would start to stink!' teacher has to reassure the class that the answer is legitimate, and as it is repeated, it is 'sanitized' from 'stink' to 'smell' to odor', and finally enters the 'science' register in terms of 'waste products.' When teacher uses 'smell' in the strongly colloquial locution 'dying from the smell' there is another outbreak of laughter, registering the abnormality of such discourse, especially by a teacher. The same happens, to a lesser degree with teacher's allusion to dishonesty (6L30) and not liking cold hot dogs (7L1-2). These occur in the context of a 'serious' analogy in the regular thematic development of the lesson, and not in isolated 'non-science' segments (cf. the 'hot, steaming yak dung' story in EL or the 'Christmas and Easter' negotiation for the pass).

In LG, laughter and the comment 'She's amazing,' respond to another student's saying 'just like a little puddle' to describe what teacher called 'a mirage' and another student before described as 'the ground looks wet' (7L27-8L8). In DRS (19L1-2) students laugh when teacher says 'Isn't that amazing!' as a comment on the major inductive discovery of the lesson in the preceding dialog. One student says 'It is!,' thus highlighting the science register norm of 'matter-of-factness.' Human reaction to, much less participation in, formulations of interesting 'regularities' in science is not consistent with the discourse norms. Nearby in the discourse (DRS 19L3-9), teacher and students laugh at the suggestion that the name of the 'B' elements could be the 'Killer B's,' both as a pun on a horror film theme, and because 'killer' is almost certainly ruled out as part of the register of introductory chemistry.

Two very different norm-violations are marked by laughter and dialog comments in DRS. In (6L506, 14-18) teacher is miming opposite rotations with his hands; a student poses the muscular coordination task of rubbing the belly while patting the head, thematically related in Common Parlance systems, and finally teacher makes the contrast 'describe that in words' vs. the gestures they have been using. The discourse of the science register is expected to be *verbally* explicit and use autonomous 'full propositions' which are independent of situational context. At the end of the lesson (20L12-21), students react to teacher's statement that gold and silver are 'found *free* in nature.' Here, and with the explicit contrast of 'this/that wasn't free' below, we find the general contrast between 'technical' and 'common parlance' usage of lexical items they share. The presumption is that one cannot rely on common parlance for 'science' register meanings.

1.3 Discourse norms and their functions

Analysis of instances such as those presented above enables us to characterize some of the discourse norms of classroom science which are both violated fairly regularly and yet maintained (because their violations are marked as somehow 'abnormal') as normative for the register. The violation of these norms is clearly associated with the use in the classroom of a discourse register that is a hybrid between 'Common Parlance' and the register of science textbooks or university lectures in science. It is through use of this hybrid, and the entailed violations of the norms of the 'pure' science register, that students may acquire the unfamiliar register through the medium of their 'native dialect' of Common Parlance. The marking of the violation as 'abnormal' serves to *separate* and *define* the science register as distinct from Common Parlance, and the occurence of such marking when the thematic context is the development of the 'serious' *science* thematic systems, and not when 'other business' is done in the lesson, as well as the differential expectations as between teacher and students in avoiding violations, serves to strengthen the separation of 'science' and 'common' thematic systems and sustain the authority of teacher as expert in the former. At the same time, certain *topics* are marked as ones which 'belong to science' and there is no doubt in the discourse concerning the *superiority* of the science systems, and their experts, in dealing with the topics their discourse arrogates to itself. Here we begin to see the deep connections between discourse norms and wider social ideologies.

The register of 'correct' and 'serious' science discourse summarizing from the examples given thus far, would be characterized by the following normative features. It should be *explicit* and *verbal* (vs. gestural, non-verbal), *fully lexicalized* (except for 'spoken symbols,' see below), *minimally elliptic*, and expressed in the form of *propositions* which are to be interpreted *independent of the situational context* of utterance, and should be *non-tautologous*, and *prima facie* of universal validity. It should exhibit the features of *written* English where these differ from colloquial: in lexical choice and syntactic structures, *without colloquial markers* ('like' 'gotta' etc.) and personal pronouns (esp. first and second person). In all these respects the register is defined by contrast with 'common parlance' colloquial language. This contrast goes further, so that: The register is marked also by use of *technical terms* and associated (idiomatic) locutions, both by those unique to it and by *specialized and divergent usage* of terms it shares with common usage. Among these are *spoken symbols* (e.g. '2P' 'O_2'), *formulas*, *mathematical symbol strings*, and references to *standardized charts*, tables, diagrams, etc. The register *avoids personification* and mention of specifically *human attributes*, agents, or types of action. It avoids 'colorful language' and emotionally reactive (again usually human) metaphors and hyperboles. It characterizes certain 'topics' as appropriate to the register and others as not; these topics are to be treated as serious. It contrasts these topics with fiction or fantasy (cf. 'movies'), implying their superior 'reality' and importance. It contrasts its thematic systems with those of Common Parlance and asserts their superiority.

Generalizing now beyond the illustrations given to the wider corpus of lessons observed and partially analyzed in this project, we can add that the register normatively avoids 'ambiguity' 'sensationalism' 'personalities' 'mystery' and purely narrative (vs. causal) accounts, and it tends to mark its rare historical references off from the primary domain of universal propositions.

Violation of these norms is most frequent in secondary school classroom discourse, much less frequent in university classes, and least often occurs in written texts. Violation is least common in extended teacher monologs, more common in teacher's dialog contributions, and is regular in student language. Many of these normative features are explicitly formulated by scientists, science teachers, and science writers and justified by them as either 'natural' to science discourse or 'desirable.' Violations are seen as 'compromises' which reduce the specifically 'scientific' character of the text or discourse but are sometimes 'helpful' in attracting students' or readers' 'interest' (cf. 'motivation') and in giving them 'a basic idea' of the science -- but to 'really do it right' one has to learn it 'properly' -- i.e. observing the norms.

However valid these accounts seem to participants, they are most usefully regarded by the analyst as data to be interpreted as an ideology shared in their community and into which students are being inducted through the discourse as surely, indeed far more surely, than they acquire the 'science' thematic systems. This notion of ideology, described in the Prolegomena, supposes that the stability of social systems, both their interaction systems and their meaning systems (mutually interdependent), is enhanced by a global subsystem of disjunctions that inhibit the realization of certain meaning connections, in part by isolating disjoint domains of meaning and action from one another. These separations are made to seem 'natural' within this ramifying sub-system of meaning relations. System stability is a *global* notion, and suggests a framework for analysis of the *interrelations* of all the beliefs and practices that contribute to (and oppose) it. Looked at in this way, what might be the wider ideological patterns in which we can view the normative features of science discourse? When a system of norms is maintained, as it is in the science classroom, *through* as well as despite frequent violations, we suspect that it is the norm-violating practices which are functional *locally* (i.e. in thematic development) and the *norm-maintaining* practices which serve only to sustain wider social ideologies whose functions are those of *global* system stability.

In a very general way, the principal disjunction of the ideology of science discourse is clearly the contrast in which it stands against what we have called Common Parlance. The narrowly 'linguistic' contrasts (e.g. nominalization, passivization, agent deletion, lexical choice), the contrasts of discourse form (e.g. 'propositional' vs. 'narrative'), the contrast of 'science'/'non-science' topics and thematic systems, the contrast of 'science-reality'/'fiction-fantasy,' and finally and perhaps centrally the contrast 'impersonal nature'/'human life' all work to strengthen, support, and reinforce one another globally across the actual hybrid, 'norm-violating' discourse of the science classroom. Students come to operate *this* ideological system of meaning relations far more reliably than they do the specific thematic systems recognized as 'science' within it. Only a small fraction of students 'master' the 'science' thematic systems of the classroom, but nearly all master its interactional system (i.e. know how students should behave and

and can use the system effectively for their own ends), and nearly all react to 'science' as something alien to the human world of Common Parlance in which they are comfortable and confident. Most students feel 'insecure' about 'science' because they do not 'understand' it and do not feel they can rely on Common Parlance understandings to help them out. Most like, if anything, the mystery, the surprise, the personal discovery of 'lab work' in science and the humor of their teacher -- and do not like the 'cold, impersonal, not-human' world of the 'real science' discourse register. It hardly needs to be said that 'eminent scientists', and many people who do and like the activities and life-world of 'science' practices, identify their world as one that is very 'human' and prized by them for this, or that any circumscription of what is and is not 'science' is entirely artificial and counter-productive except in precisely delimited contexts of its use. But these are not the messages of science discourse in the classroom or elsewhere, and such ideologies need not be regarded as mere 'accidents.' The effects of the actual messages include: The restriction to a small group of the ability to use 'scientific and technological' thematic systems for their own purposes, a component of the social distribution of power. A widespread belief that those who do operate these systems are 'naturally superior' to those who in school 'didn't have a head for science.' A general acceptance, even among scientists, that 'scientific propositions' are impersonally true about a given 'natural world' rather than social constructions that make these meanings just as, say, 'artistic' meanings are humanly made. The belief that 'science' and human emotions don't mix (the disjunction: rationality/irrationality), rather than that they are inseparable aspects of the actual human activities labeled 'science.'

The 'inhuman' character of science justifies the disinclination of the disenfranchised to claim a share of its power. The 'impersonal truth' of science justifies its use as a metaphysical grounding for social acceptance that 'some things just are as they are,' most especially 'human nature' and by implication the existing social order. And deep beneath all of these, the acceptance that context-independent 'propositions' may be categorized as 'true' -- laying the foundation for a mystification of the power of human 'authority' to assert 'truth' and through it all other 'legitimation' of power. The trail leads that far. If we do not question the possible disjuntive role, the ideological, system-stabilizing functions of the very concept of 'truth,' we have not begun to do critical analysis of 'science education,' 'education' or any other aspect of 'our own' sociosemiotic system. Let anyone who thinks there is 'no point in dragging in all this ideology stuff in analyzing science classroom discourse' try to analyze the possible system-stabilizing consequences of this very (disjunctive) belief.

The 'leaps' admittedly made in looking for the larger ideological patterns to which the ideology of science discourse norms contributes have not merely been 'unorthodox,' as they would have to be in any successful analysis of a widespread ideology in our own community, but they have necessarily carried us well beyond the particular discourse examples of these lessons. A more closely argued and documented analysis of these sorts of connections can be made, but that is not a task undertaken in this Report. From the contrast features of some stretch of discourse to issues of system stability is a long and complex path for which our present theories are insufficiently developed guides. They will become 'developed' on the pioneering journeys that remain to be taken; already they point to the need for such analyses and give us clues as to where to begin and how to proceed. In this section we have sought only to suggest this possibility, to initiate an enterprise of our own discourse-as-action through which we can make meanings otherwise 'disjoined' and enact a new meaning system that can realize more of the human possibilities of our interactions as a social community.

The rest of this chapter will look at some science classroom ideologies that surface in other ways than the discourse norms we have been considering so far.

2.0 Science Classroom Ideologies

In the course of classroom science lessons, teachers and students sometimes explicitly, and frequently implicitly, construct shared or conflicting views of the 'nature of science', both in itself and contrasted with 'other subjects' or 'non-science', and of the nature of the teaching and learning of science' in which they are engaged. In the following sections we will observe some of the ways in which this occurs and comment on the possible wider significance of these ideologies.

2.1 Evidence and Authority

The 'authority' of science derives, it is told, from 'evidence and logical argument' rather than the power relations of a social system. Unless 'science' is personified, however, we are entitled to suspect that it is *persons* who wield authority, and to recall the original of 'authority,' those *authors* who are approved and published by those with the power to do so. But the ideology of 'evidence and logic' presumes that evidence 'just exists,' not that *people* have to *decide* that something shall count as evidence; presumes that the canons of logic and argument are 'necessary truths' and not social constructs. Consider some examples of this ideology and its practices in classroom discourse.

In SC (5L1-21) a debate has begun between teacher and students with a challenge (5L1) to teacher's previous 'official' statement about fossil evidence that 'the crust has been uplifted' (4L26-30). As noted in a previous discussion, teacher's 'cautious' written 'propositional' statement uses the term 'suggests' to link evidence and conclusion, but it is also termed 'this answer' -- a written Answer to a written Question, to be copied into student notes. Charley, seconded by Vito, offers another conclusion, on its face just as 'logical' as teacher's. He concedes 'it's possible' they're right but 'we believe' the original conclusion is correct. Who is 'we' here? Certainly not teacher and students, so teacher and his community of 'experts.' Testing the firmness of this 'belief' Scott says: 'It's just a theory though.' Thematically, 'suggests' 'possible' 'believe' and 'theory' all seem to sit on the same side of parallel contrast relations, and the emphasis in 'possible' and the 'just' before 'theory' are indications of such contrasts, Vito replies to Scott's thesis, interrupting the teacher with: "It's always a theory.' But then teacher asserts 'This is fact. This is not a theory.' Theories, possibilities, hypotheses contrast with facts, truths. And teacher claims to be able -- i.e. to have the right to, in fact asserting a power to -- decide when something shall be classed on one side or the other of this contrast. Note that the existence of a contrast is a necessary condition for this kind of exercise of power, one that can mask itself as impersonal and objective. In the discourse three stressed 'fact's' foreground the contrast with three unstressed 'theory's' (5L5-9). Now we get Scott's version of the difference between 'theory' and 'fact' (in standard usage we can read 'hypothesis' for the students' 'theory') -- 'fact' requires 'proof' provided by 'measurements.' This set of thematic relations is taken up by teacher and then by other students (5L12-17). The use of 'proof' by students seems to realize a notion of certainty ('fact') based on 'scientific evidence,' namely 'measurements.' Neither teacher nor students in this lesson are operating the discourse of philosophy of science, but their discourse does reveal the contrasts at work. Teacher now proceeds to exercise 'authority,' the author of 'we believe' is named, an 'authoritative principle' is invoked --

and termed 'a theory.' Teacher engages students in a little triad dialog on definitions, and as we have analyzed in an earlier chapter, teacher then applies the principle to the present case. In (6L20-25) we find a return of the themes of evidence/proof: 'by looking' 'they prove' that what teacher said is true. "By looking" takes the role of measurements in the thematic structure (cf. observations). Ultimately teacher has claimed the authority to decide what principle is relevent here, then used that 'authority' deductively to support the ideology that science distinguishes facts from hypotheses by observation. What is significent here is that the ideological framework is shared by teacher and students, spans the whole argument, and is even strengthened by an argument that formally contradicts it (namely a deduction, from 'a theory,' with no specific 'evidence' of the usually recognized sort), in a situation in which teacher could never have gotten away with this means of 'winning' the debate in an interaction with others who had power ('authority') equal to or greater than his own.

In JR (9L8-27) teacher is in a duolog segment of the larger debate over scaling analyzed in the last chapter. A student offers his proportional growth analogy of 'a person' and 'a cell.' Teacher denies the specific part of student's argument (bigger organelles) as factually wrong (9L12-14, 'don't'), and student then challenges 'But how do you know that...' '...if there's never a cell that big' -- i.e. he claims the whole argument is hypothetical, since there aren't really giant cells. Teacher responds 'by observing' (fact) and finally (9L26-7) just exercises his power to terminate the duolog. The same contrast of fact/hypothesis and criterion of evidence-and-observation is at work here. A little later (10L24-11L6) in a student-initiated dialog, there is a misunderstanding, marked by Mr. Y's 'No.' at (10L30). Teacher has just contradicted Mr. Y's earlier 'Now you're saying that's the perfect size, O.K.?' by denying that he said such a thing, and

and denying that it's true. '*No*.' Mr. Y. protests, and does some repair work with a meta "I'm just proving, you know.' -- that is, his original statement is to be taken as *hypothesis*, where teacher responded to it as asserting *fact*. The original was a non-standard realization of 'Now let's say...' by 'Now you're saying' (or 'Now suppose you said...'). Mr. Y. continues, restating "Assume that you've got...' Teacher acknowledges the shift across the fact/hypothesis contrast by "O.K. Let's assume there's...' and Mr. Y. finally makes his point. Note that the fact/hypothesis contrast is essential to interpreting the misunderstanding, as well as to repairing it. The ideology here is implicit in the misunderstanding, and only partially explicit in 'proving' and 'assume.' Note also that the forms of expression in common parlance contrast with those of the science register in the usual ways here: 'Now you're saying...' vs. 'Let's assume there's...'. 'Now' is a colloquial marker, it has no temporal index value here. "You're saying' is personal, pronominal, and invokes human action. "Assume' is more lexically usual in written register, Mr. Y. uses it when he must (10L30). "There is' is an impersonal form, masking all human agency.

In EL (3L4seq.) teacher sets the tone of the discourse by invoking observations: 'as you saw' 'now notice,' contextualized as to time: 'last week' 'yesterday,' and place: 'between me and the door' ' in that direction,' and props: 'that spring.' He then asks (3L 17) 'which way does the *spring* move?' and two students reply *by observing* 'It's not moving.' Teacher says, 'But it is.' Apart from the thematic divergence of the 'science' system and Common Parlance in describing motion, and teacher's own claim (3L7-10) that 'the spring does not move,' analyzed in the last chapter, Teacher in effect claims here an authority of *interpretation* of what the relevant 'facts' are that supersedes observation. Indeed we recognize here an instance not only of the general 'theory-laden' character of 'facts,' i.e. the social construction of what are to be regarded as 'facts' for the purposes of a particular thematic system, but also of the frequent claim of the 'science' system that 'the facts' are exactly contrary to 'common sense' observations. We find this again in EL (7L2-15) when Teacher establishes the contrast and implies the superiority of 'science' over Common Parlance systems. The student offers 'telephone call' as an example of a 'longitudinal wave.' Teacher's main response (7L9-15) first asserts that it is not. Then we get the unusual 'sorry about that,' expressing teacher's sympathy for a wrong answer that is not really student's fault. 'I know you might think that...' contrasts with 'It really doesn't.' The student is not to blame for a Common Parlance association contradicted by science. 'You might not believe this, but...' signals again that common beliefs are often superseded by science. 'Give you an example...', then teacher introduces what has the form expected for evidence, but in fact turns out to be simply an abstract description in terms of a science thematic system introduced via the analogy of the window pole. We have previously noted that teacher could have built a hybrid thematics linking 'phone call' to wave-pulse transmission, that would have subverted, where this discourse sustains the ideological disjunction of the 'science' and 'common' systems on which the 'authority' of science seems very much to depend in classroom discourse.

2.2 Difficulty and Teacher-/Student-Competence

Turning now from ideology of 'science' to the ideology of the 'teaching and learning of science,' we examine how classroom discourse may sustain a system of beliefs about the inherent 'difficulty' of learning science, and its relation to the 'competence' of students as 'learners' and of teachers in their role.

In nearly every lesson we can find a global thematics of 'teacher/

student competence,' that is, throughout the discourse things are said and done by which teacher and students reflect on their own and each other's 'competence.' Consider some examples from LG. Before the start of the Main Lesson, teacher does a brief demo of the visible spectrum and in introducing it mentions 'an idea I hope we haven't forgotten over the weekend'(11:24:50). Despite solidary 'we' it's clear he hasn't forgotten, and the implication is that if they have, their 'competence' is in question. It is at the same time a reminder of the importance of memory. In EG, after students answer a few review questions (Old Information) acceptably, teacher says: 'Good, Memory is working, (12:28:10)'. There is a joking episode in DRS (3L1-10) where students call into question teacher's memory of his own homework assignments, and a teacher's competence often becomes the butt of student laughter if he misremembers a student name. At the end of the Demo in LG, teacher says, 'That's the whole thing with this machine, very disappointing,' (11:26:48) reflecting on their possible disappointment in his 'performance' -- whether as showmanship, or for its lack of close thematic ties to the rest of the lesson. Just before the start of the Main Lesson he asks students to formulate those thematic ties and gets a series of extended student answers, after which he says: 'That's a very good memory, but you're very smart and I expected you to remember it.' Here is an explicit link of 'memory' to 'smart', a general term for thematic competence. We are excluding for purposes of this discussion ordinary admonitions that reflect solely on student behavioral competence.

At (2L23-6), LG sets up a contrast 'simple questions'/'complicated ideas' between the inherent difficulty of science ideas and the 'ease' of learning them from a competent teacher ('so it should be a snap'), provided students 'remember from last week.' This exemplifies the underlying ideology of science teaching and learning in classroom discourse: Science is hard, but given teacher-competence and student-competence, you can learn it. Note that the extension of this, as we shall see, is that students who succeed in 'learning science' have a high degree of student-competence (are very smart) and those who do not succeed are not smart. Moreover, when students are finding the material difficult to understand, this is not supposed to depend on the material which is (i.e. has to be) hard, but must either reflect student-incompetence or teacher-incompetence. Students who are not 'understanding' -- and surely most must feel this way most of the time -- can accept their own 'incompetence' or can impugn that of teacher.

At (3L12-15) teacher is operating the science/common belief contrast: 'very few people realize' and co-opts the students on the side of scientists/ people 'now you will, and maybe you'll tell all your friends.' Some students object to this and teacher responds 'Shows how scientifically oriented you are,' impugning inevitably the student's competence as well as their interest. We note in passing that many science teachers believe there is a positive relation between how smart or competent students are and their 'interest' in science.

It should be clear that SChalls, isolated or in Teacher-Student Debates, are one way in which students question, if sometimes indirectly, teacher competence and assert their own student competence. We find this in LG (5L20-6L22), where at the end teacher raises the issue of student competence (in self-defense?): 'you should've learned a rule,' and a few lines later foregrounds his own competence in a curious way. He states a version of the principle of conservation of energy, then says, 'Well I don't know if that's true anymore either.' While 'I don't know' calls into question his competence, the whole statement is made with a glance toward the observer, whom teacher knows to be a physicist, and is in a different, quieter tone of voice, with 'colloquial' marker, invoking the community of special competence to which teacher belongs more than students, and in which 'scientists know' the latest truth about these things. He then asserts firmly the part of this 'authoritative principle' he needs to 'win' the debate. This teacher, like many, and like most students, softens the issue of teacher/student competence by humor. At (6L22-3), just after the debate, he laughs at his own clumsiness in dropping an eraser. But he knows, and students know, that handling erasers is not central to teacher competence.

The issue of teacher/student competence rises again and again in brief moments in the Lesson, when students mock teacher (6L13, 8L26), teacher mocks students (11L19), students challenge teacher (10L28, 11L1), teacher raises issues of student competence (11L9, 13L30), etc. At (12L5-7), after a student has ironically 'thanked' teacher for 'improving (their) vocabulary a little,' teacher responds in kind playing on the same theme of co-optation (you and scientists/your friends, cf. 3L12-15).

Examples of the same sort, equally numerous, could be cited from DRS; from the initial appearance of teacher competence at 'look how fancy I got' (1L13). The student norm enforcements, which implicitly criticize teacher competence, the issue of student competence (5L26, 9L9, 16L13), student implications that teacher is 'mixed up' (3L1-10, 10L20-25) or has 'made a mistake (15L21-24, 17L3-4), teacher's admission of error (12L20-22), etc. During and just after a Seatwork episode, teacher uses the theme Science-Difficult, when asked about 'the dots': 'Dots are hard' (16L11), followed immediately by a joke looking at a student's paper 'whadya put in? 36 dots?' when only seven are needed (student competence), and then (16L20-24) his public response 'it gets so confusing in the dots.' It is doubtless 'meant' sympathetically, but the core ideology is still being maintained.

It is worth noting a few more examples in EL. Student competence is a primary 'non-science' theme of this lesson from start to finish, far more so than usually. The lesson begins with the allegory of the frozen snow goose, a sort of parable of the core ideology. In outline: a peasant finds the near frozen goose, buries it in a pile of warm manure; it wakes, honks loudly, and attracts a wolf who pulls it out and then eats it. The moral: (1) he who buries you in manure is not necessarily your enemy, he who pulls you out not necessarily your friend, and (2) when up to your neck in manure, keep your mouth shut. I don't intend to give the full exegesis this deserves, but neglecting the important linkage teachers make between thematic and behavior competence of students ('don't talk in class'): the students are in trouble (it's cold, there are wolves) because science is difficult: the competent teacher can help you even though his help seems like a pile of manure; if you don't do the right thing (student competence), the wolves will get you (you'll fail). The wolf who at first seems a friend 'is' friends who distract you from the lesson, making a link to the behavioral ideology (Chapter 2) of non-social learning and individual responsibility for success and failure. After the parable, teacher 'lectures' students on their poor exam performance, due to student imcompetence, but by emphasizing behavioral non-competence (not listening in class, not studying) he leaves open the possibility of their doing better. As the Main Lesson begins, a student is denied the hall pass when she 'can't answer a question like that' (student competence). Jimmy gets a stern lecture from teacher on his competence, during which he challenges teacher for being unwilling to listen to him (1L21-2L20). Shortly after, we have teacher's lecture on taking notes to avoid failure (2L27-3L3). Under this onslaught on their competence there is relatively little counterattack by students on the teacher's.

We have previously noted how teacher maintains the science/common beliefs contrast in the 'phone calls' episode (7L7-11), which of course is part of what makes 'science' seem difficult for students. The same happens for 'water waves' (8L4-11). In (10L10-28), 2 students have trouble answering acceptably. Teacher's strong negative evaluations are revealing: 'If you put that on a test, I'd say...' 'I'd still say...no good' and later 'I'm gonna call it *wrong*.' and 'I'm gonna call *that* wrong too.' Teacher is marking this topic as Old Information, hence failure to answer acceptably is a more serious fault than with 'new information' questions, and reflects more sharply on student-competence, which is quite explicitly impugned by teacher in this episode. Note however that teacher directly invokes his 'authority' and power in these evaluations ('I'm gonna call it...' 'on a test, I'd say...'); it is teacher who pronounces answers acceptable or not. At the end of an episode in which it is clear that these, and other students, did not make the needed thematic connections, teacher pronounces the answer 'both ways' not only acceptable: 'Yeah,' but *obvious*: 'of course,' implying within the framework of the core ideology that it is students' own fault if they have not learned. Near the very end of the discussion of 'longitudinal waves' in this lesson (11L19-23) a student gives a reasonable answer that is still not the 'right,' i.e. *expected* answer. She says it very softly. Teacher's response acknowledges that her 'timidity' is connected to his power: 'O.K. I won't hit you. Alright -- it's alright. You can say it. It's not a dirty word." Under the cover of humor, teacher's power ('hit') and power to decide what is or isn't 'acceptable speech' ('dirty word') is foregrounded in an act of reassurance. The ideology of the difficulty of 'science' serves in part to legitimate the exercise by teacher -- and by all 'authority' that claims to 'know' -- of the power which in the moment is what makes 'difficulty' for students.

2.3 Strong Classifications

Having considered some features of the dominant classroom ideologies of science and science learning, in this and the next section we will take note of some additional discourse means of enacting these disjunctive systems of meaning relations. The theoretical work of Bernstein (1981) has emphasized the role of 'strong vs. weak classification' in the maintenance of ideologies and social systems ('cultural reproduction'). Where there are 'strong classifications' contrast-pair categories, especially those involving social roles, are kept 'categorically' disjoint (e.g. teacher/student). 'Weak classification' permits blurring of the distinctions, overlapping of the categories.

We certainly see such 'strong classifications' operating in the science classroom. It seems clear that, like the notion of 'norms,' these systems link the thematic and interactional aspects of discourse, as is expected if power, which is exercised inter-actionally, is to be legitimated as 'authority' through ideologies which operate in and through thematic systems and norms that link interactional practices to 'appropriate situational contexts,' which are defined as much thematically ('this is serious' 'this is not science') as interactionally. We have already noted the science/common belief contrast, and the related science register/common parlance contrast. 'Science' is strongly classified not only against 'common belief' but also as a subject vis-a-vis other subjects, e.g. vs. 'geometry' (JR8L12-19), vs. 'English' (KF3L29). Just as the classification against common belief enables teacher to exercise the power to deny 'scientific truth' to such beliefs and rob students of their familiar thematic systems, thereby weakening them relative to teacher (and teacher's community of 'scientists'), so the classification against other school subjects insulates teachers from use by students of the 'authority' of other teachers, and further deprives students of the use of other specialized thematic systems that may be more familiar. When connections are made across subject lines, the event is marked as 'special,' and students will often object if teachers ask them to perform a task they have been taught 'belongs' to another subject.

Interactionally, of course, it is the 'teacher/student competence' ideology which best exemplifies the maintenance of role relations that keep teachers from 'acting like students' and students from 'acting like teachers.' The contrast between these roles is also maintained by the interactional structures, which assign moves to teacher or student (e.g. TQ, TNOM, SA, etc. of triad dialog), and by such discourse features as the tendency we have noted for students to use colloquial forms unless they must use the written forms of science register, while teacher's use of the colloquial is considered humorous, friendly, or norm-violating. Apart from role-relations per se, the interactional situation-types science class themselves present some strong classifications. 'Business' sittypes: making Announcements or Assignments, Calling-the-roll, handing out or collecting papers, contrast with 'Teaching' sittypes, as do Confrontations, Lectures, and a few others. In Business episodes, TQs are not of the 'known information' type and dialog is True Dialog not Triad Dialog. Business episodes do not contribute to development of 'science' thematic systems in the discourse. In the 'Business' sittypes there is plentiful human agency and human action, precisely as there is not in 'content teaching' episodes.

A particular contrast of this kind that is not limited to particular sittypes is the contrast personal discourse/science discourse , where there is often an intonational, prosodic, or paralinguistic contrast, as well as contrasts of segments with and without personal (or pronominal) subjects, and with and without human action verbs. 'Personal discourse' consists largely of teacher's 'personal comments' in the course of the lesson, comments that contribute mainly to defining a particular sort of teacher/student relationship or 'tone' in the class, rather than developing a science thematic system, or getting any business done (including the 'business' of admonition). These may coincide with sittype-defining metas, or occur as or in Interrupts. In the first episode of DRS these features set apart teacher's utterances at (1L11, 13, 2L8, 2L18, 21-2) in the 'personal' category. One can also regard this contrast as a special one within the science/common parlance register contrast already discussed.

2.4 Metaphor and Syntax

The disjunctive meaning relations that constitute an ideology may also be realized in discourse through patterns of 'metaphoric' usage and through patterns of choice among syntactic alternatives. A 'metaphor' is a usage that may or may not be recognized as such by participants. When it is so recognized (overt metaphor), the dimentsion 'metaphoric/literal' is added to its meaning potential, and that dimentsion can carry additional significations such as 'exaggeration' 'humor' 'implied analogy' etc. Even if not so recognized, and in issues of ideology especially when not recognized, the analyst may construe a usage as covert metaphor when another usage of the same form exists in the speech community of the participants and that usage permits an alternate contextualizing connection to the thematics of the original usage.

Consider first the usage of 'die' in JR. The first occurence is in (6L12) by T: 'The people in the middle would be dying from the smell.' This is an overt metaphor: participants know that 'dying' here is in contrast with other 'literal' usages, primarily for human death, and thus 'dying from the smell' is hyperbole via metaphor. At (7L11) just after the teacher has reintroduced 'the cell,' after summarizing the conclusions from the crowd analogy, a student says 'It'd die.' That is, the cell would die. 'Die' here is a covert metaphor, analogizing cell to human death. Common Parlance of course does not have its own 'semantic rules' for cells, but cells are classed here as 'living things' (cf. equivalence at (4L3 to 3L29), and saying they can 'die' further builds this thematic relation. The metaphor is covert because the discourse does not concern itself here with what human death and 'cell death' have in common, though it assumes (covertly) such a relation. At (7L21) teacher says 'so the stuff in the center would end up dying.' Comparison to (6L12) clearly indicates the analogical character of this metaphor, presumably overt with respect to teacher's discourse (the science register does not permit us to speak 'literally' of 'nucleus death' in the way 'cell death' is permitted), but likely not so for students, though it still functions to connect the cell and crowd thematic systems for them, as subsequent discourse shows. It should not escape many readers' notice that the covert metaphors of life/death that extend human life/death to 'cell life/death' are part of a powerful ideological system that is fully in evidence when people say human 'life begins at conception' or 'abortion is murder' (even when the abortee is a single cell, supposed 'special' because it has the 'potential' to become a human being, though of course every cell has that 'potential' under special environmental conditions, and no cell has it otherwise).

An interesting covert metaphor occurs in the first episode of DRS. The thematic system of spatial localization is used metaphorically throughout the episode to describe aspects of atomic structure. It is a 'modeling' use of metaphor in which both its usual sense (deictic reference to the board diagram representation) and a metaphoric sense ('imagine the atom as if...') are available. The first covert use, at '3-dimensional' is developed in later discourse (6L27-7L1) to 'fat and skinny' an overt, humorous metaphor. Then at (1L22) 'somewhere in there' extends the idea of 'an object in a place' to an electron in an orbital. 'Orbitals' are not, in the science thematic system where they have their meaning relations, 'places,' nor is the relation of electron to orbital as being 'in' it (cf. 2L5-7) the same notion as 'object in a place' in common parlance, except metaphorically. The usual and extended, metaphoric uses are combined in (2L12) 'one here...one here,' pointing to the diagram on the board. When we come to (2L17-21), the spatial metaphors become quite prominent, and teacher is speaking a hybrid thematic system that differs significantly from the science system he is trying to develop. The term 'confining' almost reverses the standard usage and reifies the orbitals enabling them to 'coerce' the electrons, rather than being mere representations of the interactional relations of electrons and nucleus. The definition of 'orbital' as a region (a 'place') is also non-standard. 'Occupy' seems a harmless lexical variant of 'be within', but later (8L18-21, 24-30) the spatial metaphor again gets reified: 'two things cannot be in same place at the same time' is applied to two electrons 'in' an orbital. Finally, 'size, shape, or space orientation,' as we have seen is a metaphoric naming of the differences between orbitals already implicit in the term-symbol (e.g. 2Px, 2S) system teacher and students have been using, and one that is standard in the science register. What is ideologically interesting about these metaphors is revealed by the grounds of original objections to and the present-day conflict between the reifying metaphors of Common Parlance and pre-quantum theory science. Thematics of reality in 'traditional' views tend to take the model of fixed, given, definable, material entities and thereby to limit us to the kinds of relations (e.g. 'within' 'confining' 'occupying space') recognized in the thematics of such entities. On the working assumption for ideological analysis of metaphors that their 'literal' or original primary thematic system is that of human actions, the ideology of 'entities' is ultimately the ideology of 'human idividuals' as fixed, given, definable, material entities. I suspect many readers may be sufficiently 'inside' this ideology to find it difficult to perceive as such; try to imagine it as a 'ridiculous, quaint, primitive belief,' try to imagine alternatives, or at least circumstances in which it might not provide a fully satisfactory basis for 'thinking a problem through.' Its metaphorical extension to atoms and 'quantum phenomena' is of course thoroughly unsatisfactory. It is only the creation of a disjunction, quantum domain vs. classical domain, that insulates the critique of spatially separated entities from contact with traditional usages of this way of talking, keeps it from being suspect *whenever* it is used.

Syntax itself carries meaning relations and may be constitutive of an ideological system. As with its role in thematic development in general, there are two ways in which syntax may do this. Local choices of syntactic structures constitute meaning relations *within* the clause, but those same choices constitute *global* patterns of distribution across stretches of discourse (or between discourses) of the clause-level relation-types. In the first episode of DRS, for example, the modality choice 'could be represented' in (1L18) foregrounds the possibility that either one of two elements might be described in part by the diagram referred to. The modality choice 'is being represented' in (2L5-7) is *unmarked* for modality when it occurs in its own clause (locally), but globally, in relation to (1L18) it has a *contrastive* modality that carries the information that electron configurations, unlike orbital diagrams, should be taken as representing a unique element, the possibility of choice not occurring. Of course other features of the clauses also help constitute this contrast (e.g. singular vs. plural subjects). More globally, it is not surprising to find in this brief episode that the 'science thematics' are realized, so far as full clause types are concerned, entirely by *relational* syntactic structures (in the narrow sense of the clause typology of functional grammar, cf. Halliday, 1981): attributive, identifying, circumstantial, and possessive, including metaphorical substitutes for these such as the use of 'occupy.' All the material and mental process clause types deal on the other hand with themes of classroom events. Reinforcing this, and not syntactically independent, human actors appear in the latter, and not in the former. The world of science thematic systems is the world of 'what is'; it contrasts with the classroom -- and common parlance -- world where 'people do.' This is not an isolated instance; it is a common syntactic disjunction and tends to place 'scientific facts' and 'science' in general apparently outside the world of human choice and action. The core ideology here is: *This is how the world is* in disjunctive contrast with *This is a meaning some people find it useful to make.* If what is is 'made by human choice and action,' it can be changed. But what simply 'is' is disjoined from what we think _to_ change.

In the 'pure' written science register, the most frequently noted special characteristics are passivization with agent deletion and nominalization. Consider DRS (1L16) and (1L18). In the latter we have a passive, with the agent deleted. We might reconstruct this as "What two elements could we represent by such a diagram?' The 'we' implicitly poses the question as to _who_ 'we' are -- who uses such diagrams? what for? and why do they? In place of 'we,' a 'you' would be a marked form, presupposing a 'Can _you_ use such a diagram to represent elements?' with its implicit 'Should you?' and 'When?' All these considerations are inhibited (backgrounded) by the passivization and agent deletion in the original text. We have 'This represents Hydrogen' without 'Who says so?' or 'When?' We are also left with what is by functional criteria a relational clause; the material process that in the active voice connects 'we/you' with 'diagram' and 'elements' effectively disappears. Without the human agency we have only 'Such a diagram represents what two elements?' which only establishes an abstract relationship between 'diagram' and 'elements.' We would not ask 'What is the diagram doing to the elements?' in the way we could ask 'What are you doing?' and get the reply 'Making a representation of these elements...' Passivization with agent deletion has created a functionally merely relational clause from a material-process structure. In (1L16) we have an overtly relational structure, realizing the same thematic meaning relation as (1L18). This is made possible by the nominalization: 'representation.' Halliday (1978) has pointed out that nominalization puts at our disposal the powerful system of meaning distinctions that can be made with relational structures. But in doing this nominalization also frequently, as here, covers up an agent deletion. We don't 'miss the agent' nearly as much in (1L16) as in (1L18); we don't ordinarily think to ask 'a representation by who?'

In the previous Chapter we have presented a number of other syntactic devices in thematic development. The use of syntactic analysis, especially of the global contextualization and distribution of particular syntactic functions and structures in relation to thematic systems, when combined with cohesion analysis, should provide a powerful tool in the future for explicating the constitution of ideological systems through discourse.

CHAPTER 5: CLASSROOM DISCOURSE AND COMMUNICATIVE ENGAGEMENT

1.0 Action and Engagement

From its earliest stages this project has been concerned with characterizing the overall interactional configuration of classroom lessons. Other observers and I made detailed fieldnotes in every class to supplement the audiotape record and several classes which had been observed in this way were also subsequently videotaped. It is customary to distinguish 'verbal' and 'non-verbal' channels of communication, but close analysis (e.g. Birdwhistle 1970, Kendon 1973, Scheflen 1975) shows that there is a single 'flow of behavior' (cf. Mathiot 1982) on the part of individuals or dyads or groups, their jointly enacted behavioral-interactional 'performance'. We look therefore for overall *patterns of action* in the classroom that include both speech and non-linguistic behavior, with the same functional move being realized now by one, now by another mode of behavior. Throughout this Report we have been using the term *discourse* for a system of *actions*, not limited to speech, and have often noted the nonverbal features of the discurse in characterizing its interational structure and thematic development. In this chapter we will identify a global feature of the interactional pattern: the overall *communicative engagement* of participants in a common focus of public discourse. This feature varies significantly over the course of a lesson, and its variations outline for the group as a whole those interactional structures and thematic development strategies we have so far analyzed mainly in terms of the behavior of a few 'central' participants at any one time. Of particular interest is the relation of student communicative engagement with the public focus of the discourse to its 'normal' *vs*. 'norm-violating' character at various times during the lesson.

1.1 Student communicative engagement

When classroom discourse is analyzed locally (over short stretches) the actions of only a few participants are foregrounded: it is these actions which define the situation-type and carry forward the thematic development. But what are the other participants doing? In our analyses of the Start Lesson and End Lesson routines of the classroom, we found that participants bid, ratify, counterbid, and in effect negotiate the conjoint accomplishment of these shifts of sittype. So do they also, if less overtly, less saliently, co-operate implicitly in the maintenance of the overall Lesson sittype.

Just as within the activity structures of a lesson (e.g. Triad Dialog) some moves may be realized nonverbally as well as verbally (e.g. bids and nominations), so in the overall interactional pattern of all participants in the lesson, enactment of a sittype, especially maintenance of the Lesson sittype is constituted (and may lapse) thru both their verbal and nonverbal actions. If teacher is speaking, and at the same time no one is looking to teacher, or taking notes, or looking at something teacher has indicated, but students are variously talking to one another, looking out the window, reading, working on homework, etc., we and participants consider no Lesson to be taking place. It may be pre-Lesson, or post-Lesson, or general non-cooperation. This is the state of zero student communicative engagement with a common focus of discourse.

In a lesson there may be periods when teacher is speaking in public voice 'to the class', or writing at the board, or engaging in duolog with one student on a 'science' theme, and only about 20% of the students are looking at the teacher, or writing in their notebooks, and the rest are talking to one another, looking about the room and otherwise showing signs of being disengaged from the 'official' common focus discourse of the teacher and a small minority of students. This is a state of *low* overall student communicative engagement. Earlier or later in the same lesson 90% of the students may be looking at teacher, with many learning forward toward teacher or posturally oriented to him or to her. Or a third of the class may have hands raised to bid to answer a TQ, or 80% respond in Chorus, or all but 2 or 3 in a class of 25-30 be copying in their notebooks what teacher is writing on the board while there are no side-conversation groups active. These are typical states of *high* overall student communicative engagement.

So long as the Lesson state is in effect, teacher and those students who are directly and overtly interacting with him or her, define a common focus of public discourse. The *degree of student communicative engagement* (hereafter symbolized by 'G') is determined by evidence of what percentage of the class appear by various *indices* (see section 1.2 below) to be engaged with or attending to that common focus rather than to some *other* focus of interaction. The common focus discourse need not be centered on teacher's speech; in dialog it may center on a student's speech, in a Demo on a displayed object, in Seatwork or Copying Notes on participation in these activities. Disengagement is always a behavioral norm-violation, but those actions which compete with the official focus and are likely to distract other participants from it are more likely to be admonished (see Chapter 2).

We are not concerned in this analysis with the 'state of mind' of individual students, with whether they are 'really paying attention' or not. 'G' is not a psychological or individual, but a behavioral, interactional, social construct which describes the overall activity state of the group in a particular way. The validity and usefulness of G does not depend on correct inferences about individuals, but on its significant covariation with *other* social interaction phenomena defined independently of it. The G concept rests on the crucial observation that most of the time in classrooms participants' behavior is restricted to a narrow range of behavioral diversity and within that range participants tend to enact the same behaviors in the same ways at the same times as other participants.

This phenomenon is especially in evidence at times when there is rapidly increasing or rapidly decreasing G. The analysis of the variation of G over the course of a lesson gives the impression that there is a 'base-line' G, a usual level of overall engagement. When G rises above this it tends to do so quickly (say from G of 70% to 90% in a few seconds), many students responding in the same way at the same time. Then, usually more slowly, G drops back to the base-level. G may also fall below the base-level, though this tends to happen more slowly, except in special circumstances (e.g. at episode boundaries) where again many students will all disengage at about the same time. The base-line level of course differs greatly from one class or lesson to another, and all reference to high/low G, and rising/falling G is relative to the lesson base-line. It should also be noted that once G has risen to a high G state, this high level often persists for a few to several minutes, with brief drops in G soon returning to the high level, as if there were a second, high-level base line with its own equilibrium G: this longer term normal-to-high shift is thus a kind of 'phase change' in the language of thermodynamics of complex systems. There is a similar metastability to low G states, but the teacher normally makes overt and direct efforts to limit their duration. It should be remembered throughout the chapter that G-analysis is basically qualitative in character. Despite the superficial quantification of reckoning G levels by percentages of students in various categories (and this can be done with high reliability) ultimately it is only the qualitative trends and major shifts of G which enter into interesting relationships with the structure and development of classroom discourse.

1.2 Indices of Engagement

A survey of the literature on nonverbal communication undertaken in preparation for this project (Lemke, 1979) indicated that a variety of nonverbal behaviors could be taken as indices of communicative engagement or disengagement. Of these the two that proved most useful were Gaze Direction and Postural Orientation. The direction of a student's gaze, when engaged, is normally to the teacher, the board or displayed material, or to notebooks, homeworks papers, or texts. G cannot be estimated apart from situational context. When the board is blank or has nothing on it of immediate relevance to the verbal discourse, and there is a Teacher Monolog, Gaze-to-Teacher is the primary index of engagement. During Seatwork, or Copying Notes, Gaze-to-Teacher may be irrelevant in assessing engagement. Actions which are 'on task' or consensually 'appropriate' in a given sittype count as engagement. When a student is disengaged, gaze is typically to another student (but not one who is central to the public discourse at that moment), around the room, out the window or door, or to some non-lesson materials at their seat (e.g. magazine, work for another course, private notes). Postural orientation is normally forward, but if teacher's location shifts, e.g. to the side chalkboard, re-orientation indicates strong engagement (mere shift of gaze direction indicates normal engagement). Forward Lean, a special posture, also marks intent engagement, though not necessarily to teacher or common focus activities. Postures often orient to competing foci, most often verso to another student.

Other indices of G include: activity shofts, such as beginning to write when teacher has made an 'official' statement or when copying from the board; number of hands raised to bid (relative to the norm for that class and lesson); number of students engaged in side-conversations; vocal expression of affect (e.g. groans, laughs) following common focus events; frequency of student initiaties; facial expression reponses (e.g. smiles, looks of doubt, concentration, dismay, incomprehension). When side-conversations are 'on topic' they often result in SQs or bids for SAs and count as symptoms of high G, not of disengagement, though it is difficult to judge this except retrospectively (after the SQ, say) or when the side itself is overheard by an observer (rarely audible on tapes). Fortuneately all these indices tend to coincide and the 'marked' states of high G and low G, as well as the processes of relatively rapidly rising or falling G levels are easily noted (overdetermined). Our fieldnotes usually indicate the criterion used and the number or percentage of students engaged or disengaged. Two trained observers agreed 90% of the time within 10% on estimates of overall G, and tended to note the same shifts of G up or down. This agreement was in fact much better than expected and indicates the high salience and overdetermined character of these phenomena.

The prinicpal limitations of observer G assessment are those of scale. Individual orienting and resonse behaviors fluctuate on a time scale of the order of a few to several seconds, about the time it takes for the observer to visually scan and count the number of clearly engaged or disengaged students (whichever is smaller) when the class size ranges up to about 40. For larger groups the situational context and G level may have changed significantly between the start and end of such a count. It may then be possible only to record in the fieldnotes 'brief G up' and the time. When counting number of the order of magnitude 10, an error of ±1 in the count, under the circumstances of classroom observation, is also not unlikely and is about the same size 'error' that would result from expected shifts of individual gaze, say, during the count. Thus one does not expect greater accuracy or reliability than ±10%, and the interobserver agreement for G here is as great as possible. (With groups of more than 40 individuals, the procedures used are not reliable, but this applies only to the large university lecture classes observed, and that data is not included in the analyses of this chapter.)

Verification of the foregoing estimates is provided by the videotape records. Comparison with observer fieldnotes for the same lessons shows that where precise comparisons are possible (about 80% of the G estimates are timed precisely enough to be directly checked against videotape evidence) stop-action counts from the tapes agree to within 10% with those of the fieldnotes. It is even possible to identify reasons for the few discrepancies between the two observers, usually due to unusually rapid shifts of G index beahviors. Some comparisons could not be made because the videocamera did not scan the whole class during the time period indicated in the fieldnotes.

Videotapes verify that G is unstable over very short time spans, being stable only in longer averaging. There is no evidence thus far that the fluctuations in G are significant for structural or thematic processes of the lesson, though no doubt they do play a role in the microinteractions that determine interactional synchronizations and rhythms in the group.

Overall, one may have great confidence in the estimates of G in our data.

2.0 Patterns of Variation in Engagement ('G')

The construct of student communicative engagement is of little intrinsic interest. As an overall index it neglects the richly complex detail of classroom interaction patterns. But it is of interest to know, for example, _when_ in terms of the structure and thematic development of the discourse, G rises or remains high, and when it falls or remains low.

2.1 Variation with interactional structures

We have already from time to time (and especially in Chapter 1) notes some of the shifts in overall classroom interaction patterns associated with the activity structures of various situation-types and transitions between them. We expect to and do find these reflected in variations in G. Thus G is near zero in the pre-Lesson period, though it seems to show an interesting quasi-periodic oscillation, rising to 50-60% for periods of the order of 2 seconds, then dropping back to zero. This is most common when teacher's Bid Start is much delayed past the Bell, almost as if functioning as a collective Bid Start by the class, or at least as a sign of anticipation of an opening move by teacher. After that opening move, there is usually a rise of G to at least 60%, and then over widely varying times of several seconds to a minute or more an initial maximum of 80-90% is achieved. This rise is associated with the first 'important business' of the Lesson. In DRS it is the first difficult TQ in the Review, in LG and JR an announcement about class Business, in EL it is the start of the norm-violating 'snow goose' narrative, in KF a seatwork assignment. When the first peak is part of a pre-Head structure or the development of a 'non-science' theme, G usually drops again _below_ base-level and then gradually rises again to base-level or above when 'science' thematics begin to dominate the discourse.

In Triad Dialog G rises at each new, main TQ and drops with the nomination. It also regularly rises at TNegEvals, especially if a student is 'in trouble' answering. At structural boundaries, G invariably drops rapidly and sharply to below base-level and rises again only when both (1) a new structural segment or sittype has been interactively defined and (2) a science theme or important non-science theme introduced. If this does not happen within a few seconds, a liminal sittype develops (see Chapter 1). G tends also to be high at the beginning of TMonologs and to decline monotonically during them, as it does during Seatwork. G declines rapidly to below base-level during most Teacher-Student Duologs. It rises at teacher's response to a student initiative, and will stay high during a Debate. It is high during Demos. Toward the end of the 'official period' G will drop sharply, and in some classes this Bid End may be repeated one or more times, especially when there is uncertainty about when the period should end. Note also that G is usually high when teacher is writing notes on the board to be copied, declining slowly during Copying Notes.

2.2 Variation with thematic development: 'Normal' strategies

We come now to the most interesting results of the G-analysis. One of the original concerns of this study was to investigate the occurence in classroom discourse of violations of the 'stylistic' norms of 'scientific discourse'. How extensive is the norm-vilating mode? what forms does it take? and how is it related to students' communicative engagement with the lesson?

The initial hypothesis was that there was relatively little norm-violation in science classrooms (though more than in written science discourse, and more in secondary school than in university classes), but that norma-violating discourse would be associated with greater communicative engagement. We have seen in Chpater 4 that these norm-violations are usually indirectly and often directly noted by participants, and that the norms of 'pure' scientific discourse enforee an ideology of the 'special character' of scientific discourse which alienates it from both Common Parlance and the 'human-centered' features of the common register. Violation of the norms presumably has two effects: the effect of 'novelty' and the effect of making science more accessible to those who comfortably operate the thematics of common parlance, including its 'human' orientation. Both of these effects should be associated with greater G.

To examine this problem all occurences of norm-violations and all instances of markedly rising G and periods of high G were identified in 5 lessons (DRS, LG, JR, EL, and KF) for the untranscribed as well as the transcribed portions. Comparison showed relatively little difference in the extent of norm-violations in the transcribed and untranscribed portions, though some subtler violations may have been missed without transcriptions. The G-analysis in no way depended on transcription, but fieldnote estimates of G were supplemented by audio evidence (e.g. the end of substantial audible siding as an index of rising G, a large Chorus answer as index of high G, etc.). In each lesson all cases of high or sharply rising G (hereafter +G) were examined to see (1) if there was an associated norm-violation, and (2) what other features of thematic development might co-occur with +G. Then all instances of norm-violations were examined to see whether they were associated with clear indications of +G or not.

The first result of the G-analysis was that 52% of cases of high or rising G are associated with norm-violations. While this makes norm-violations by far the single most frequent associated feature of +G, about half the times of +G occur during 'normal' discourse. So we will 'detour' here from consideration of the major hypothesis to report the most commonly associated discourse features of high and sharply rising student communicative engagement during 'normal' discourse.

G is almost invariably judged to be high during periods of silence. These normally occur when students are copying notes or engaged in seatwork. Since disengagement in these lessons usually leads to siding, silence is generally associated with on-task activity. In such periods there is no verbal discourse to count as either norm-violating or normal. A small number of such cases have been excluded in figuring the probabilities of +G for 'normal' and 'norm-violating'verbal discourse (section 2.3).

When teacher writes at the board, this is both a structural signal for the Copying Notes sittype and also a marker that the verbal discourse is thematically important. +G is regularly observed in circumstances where verbal discourse may be taken to be specially important to thematic development as judged by students. This relation of Importance to +G is the basis of teacher use of marked Importance as a control strategy (cf. Chapter 2, sec. 3.2; Chapter 3, secs. 4.1 and 4.2), as in DRS (17L30-18L3) or in the common use of Copying Notes for interactional control. Thus we find +G when discourse is marked as New Information (in Announcements as well as 'science' information) and when a thematic development is marked as Difficult.

New Information cases account for 10% of the normal-discourse +G observations (i.e. about 5% of all +G). Nexus TQs and other explicitly marked 'difficult' TQs, 5%. Points of full Teacher Explanations, 14.5%. Marked Importance, including board writing in about half these cases, 26.5%. Drawing diagrams and displaying apparatus or special materials is identified for about 12%. About another 7% involve cases of what we might call instances of 'trouble' of 'trouble': a student is having dificult formulating an acceptable answer, a student is admonished, there is a confrontation or a calling into question of teacher- or student-competence. About 6% are associated with the start of a structural unit.

This kind of category outning report of results is not in itself a very enlightening mode of analysis. It ignores contextualization and most of the local meaning of the events counted. While for statistical purposes one wishes to assign events to mutually exclusive categories (as has been done above), there is no theoretical basis for choosing a set of such categories. A particular discourse event may be explicitly marked as a 'difficult' point and also be structurally and functionally a TExplan. It is only impressionistically that one classifies together the various kinds of 'trouble', and even if participants themselves make some such category explicit, it is only from the local contexts of its instances that its global meaning can be inferred by the analyst. It is pointless to reify these categories and ask, say, whether they 'cause' +G, or to compile statistics on what fraction of events so defined do or do not involve +G. It makes as much sense to take +G as defining interactively the perceived importance of discourse events and then to look for the local discourse features, structural and/or thematic, that are associated with such +G in more than a few isolated cases. This is how what has been done in this section should be interpreted.

2.3 Variation with thematic development: 'Norm-violating' strategies

We have already noted that approximately half of all instances of +G are associated with violations of the thematic system norms of the 'science ' register (described in Chapter 4). The overall extent of such norm-violating discourse, estimated in terms of lines of transcript, for our 5 lessons has an upper limit of 15-20 %. To the extent that there is any systematic bias in these transcribed portions of the lessons, and in the lessons selected for detailed analysis, it is that norm-violations are more extensive in them than in the corpus as a whole.

Each case of a norm-violation was checked for associated +G, which was clearly indicated in 77 out of the 87 cases (89%). This was done on the 5 lessons in their entirely, untrasncribed as well as transcribed portions. Since about half the instances of +G are not associated with norm-violations at all, the signficance of the 89% result needs to be checked against the probability of +G in the absence of norm-violations. A conditional probability analysis was made, incorporating an estimate of the overall incidence of +G in the sample. This estimate was made on the basis of the fraction of lines of transcript that would fall in the high G periods or be associated with rising G, and to err on the conservative side, this estimate was figured as an upper limit also. Since the transcribed portions of the lessons are already biased toward a high value for this figure, we can feel quite confident that it dees not in the corpus as a whole exceed the 40% upper limit obtained for the transcribed portions. In fact, the figure for DRS (whole lesson transcribed) and LG (two-thirds transcribed) is only 33%, and the value for the corpus as a whole is almost certainly below this figure as well. Using the 40% estimate, the conditional probability for +G given no norm violation in the associated text is 0.26 (using 33%, it is 0.20). Thus there is three to four times as great a likelihood of +G in norm-violating discourse compared to 'normal' discourse. (For the sample sizes of approximately 70-100 cases, this difference is clearly statistically significant; indeed it is so far from what might be encountered as a chance fluctuation or sampling error that the roughness of our estimates is irrelevant to the reliability of the final conclusion.)

Norm-violating discourse is a minor fraction of all science classroom discourse, but it is far more closely associated with high student communicative engagement than is 'normal' discourse. Despite the regular pattern of efforts by teachers to maximize +G, the norms of the 'scientific register', enforced even by students (cf. Chapter 4), inhibit precisely the kind of discourse most closely associated with +G and hence keep +G itself from occuring over a larger portion of classroom science lessons. If we take +G to be a necessary condition of mastering 'science' thematic systems, then the processes of science classroom discourse reflect the functional priority of the maintenance of the underlying ideology of the 'science register' norms over the development of students' mastery of 'science' thematic systems.

It is important finally to specify, beyond what we have already done in Chapter 4, just what discourse features these are that we count in this analysis as norm-violating and which are so closely associated with high and rising student communicative engagement.

The original protocols for observers called attention to the following categories of norm-violations, for which we provide actual examples:

Personal/human reference

LG: 'Remember me? the old guy that gets paid -'
'Is this the Rosie we knew in junior high school?'
'That water vapor ... in my breath'
KF: 'What was the first step that you took, Smiley?

Historical reference

DRS: 'That's how Einstein made his fortune'
N.B. The norm-violating character is as much due here to reference to the material rewards of science

Social relevance

JR: 'There's a rally on Wall St. to stop nuclear reactors'

N.B. This category is quite rare, usually limited to a specific application of a science theme in medicine, agriculture, or economically important technology

Reference to Daily Life

LG: 'I want you to think now ... about our lives everyday'

This is part of a contrast of everyday life with 'some abstract ideas' (12L12-14L6)

JR: '...rarely get mugged on the subway'

Fantasy/Mystery/Imagination

LG: '...and it has a very special name' ((mystery about the name))

JR: 'this tiny blob goes round, and what it does is it easts people' ((fantasy))

Humor

(This was found not to be a separate category of norm-violation. The incongruity that makes a discourse event funny represents its divergence from a specific register norm.)

Expanded versions

(This was a category of the original scheme contrasting with the 'terse prose' norm of written science discourse. We find expanded version in TExplans and TSumms of terse'official' versions written at the board, but students do not respond to these as norm-violations.)

Colloquial language

DRS: 'They're fat and skinny'

JR: 'The people in the middle would be dying from the smell'

'Non-science' topics

DRS: 'Not the Killer Bs' ((movies))

LG: 'Star Trek and The Planet of the Lost Chicken' ((TV))

JR: 'There's a movie... with Steve McQueen in it'

KF: 'the CIA agent'

Bizarre or emotive language

DRS: 'the Hund rule' ((with exaggerated guttural voice))

EL: 'a pile of steaming yak dung'

KF: 'we use pickled rope'

Having analyzed many instances of such norm-violations in their discourse contexts, it is possible to make some fairly reliable generalizations as to the norms which are violated and the underlying ideologies in which they function (cf. Chapter 4). But it is important to note first that the occurence of violations, both because they are often marked (e.g. by humor signals, by students' norm-enforcing comments) *as* violations, and because they are often thematically isolated from the 'science' themes, or placed in contrast with them, serves to *maintain* the norms and their underlying ideological disjunctions. Thus *personal* references are usually to 'non-science' activities. LG's breathing water vapor is a fairly rare exception. The *historical* person 'Einstein' has only the most tenuous link to the themes of electromagnetism in that episode, but is here cited for his having 'made his fortune', which is a genuine violation of the norm of the 'disinterestedness' of scientific activity. The 'Wall St.' rally reference has nothing to do with capitalists or the dangers of the nuclear power indistry; it is thematically just developed as an instance of any large crowd of people. In LG 'everyday life' is contrasted explicitly with the science themes. The 'non-science' topics are all reacted to as norm-violations as are the examples in the last category above.

Some of the discourse which is reacted to as norm-violating, but does not easily fit this initial set of categories will help us characterize the norms at work. In DRS there is a *contrast* of 'body language' and 'words' and in EL a similar sort of joke is made about gestural answers to questions (9L17-20). These and other cases foreground the norm that scientific discourse should be *verbally* *explicit*, *referential* discourse. This norm also works against the use of *metaphor*, itself a category of norm-violation except where the metaphors are accepted, standard ones no longer responded to as such (Chapter 4, sec. 2.4). DRS 'hotel for electrons' is not acceptable. Similarly personification (cf.'Mother Nature,huh?' in DRS) and anthropomorphism (DRS: 'They like to?' of electron pairing) are especially unwelcome because of their connotations of human agency, which is thoroughly backgrounded in the 'science' register. Science is also supposed to be 'humble', hence the norm-violating irony of KF's 'your words of wisdom', and above all it must be 'honest', making it necessarily funny when in KF teacher makes it obvious that he is tilting a meter to get the reading he wants in a Demo that is not going as expected. When in DRS teacher and a student joke about whether the gold of a ring is 'found free in nature' or not, the contrast of 'science' and 'common parlance' thematics is also a contrast that excludes discussion of economic value from what is 'normal', i.e. 'truly scientific' in science discourse.

In terms of the norms of the 'scientific register' and the 'normal/norm-violaitng' contrast of 'science' and 'common parlance' thematic systems, science should be: serious, objective, impersonal, unemotional, honest, humble, matter-of-fact, disinterested, rational, logical, non-exaggerating, non-metaphoric, unpoetic, verbally explicit, referential, technical, specialized, and difficult to understand. It describes a world that is not that of the human activity of the social construction of meanings; its meanings and themes are distinct from those of common speech and everyday life. Only its 'applications' and not it itself are matters of social policy, interdependent with human economic and political activity. It correspondingly eschews fantasy, mystery, speculation, playfulness, humor, emotive language or themes, emphasis on people as actors, especially their ordinary human characteristics or 'personalities', concern with moral, ethical, or social value, nonverbal or non-referential modes of communication, implicit meaning, ambiguity, polysemy, imagery, and colloquial topics and language outside the 'canon' of what-is-science.

Such is the ideology of science constituted by the disjunctions that separate 'science' from most of the rest of human activity. Combined with the classroom ideology that you have to be 'smart' to 'understand' science, this 'difficult subject', it tends to insure that those exposed to it through such discourse will leave 'science' to 'the scientists', who -- at least in 'scientific matters' -- know about this 'world that is as it is', not 'made' by us and not up to us to change. For the most part even the norm-violations that do occur and the associated high levels of student communicative engagement still contribute to such an overall view of science and their own relationship to it on the part of the participants in science classroom discourse.

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NSF PROJECT: Classroom Communication of Science

PRELIMINARY NOTES ON OBSERVATION PROTOCOLS

J.L. Lemke

I. Focussed observation protocol

The observer's fieldnotes will be used as a record of the dimensions of classroom activity not picked-up by the audiotape recording. Some audible information, however, is needed in the fieldnotes: (1) to help establish correlations with the tape in respect of time and situation, and (2) where significant audible events might easily be missed in reviewing only the tape.

The observer will primarily focus on these areas:

A. Signs of student communicative engagement ("G")
B. Occurrence of style and content features of interest ("F")
C. Critical events
D. Special non-audio information
E. Dimensions of situation

A. Communicative engagement (G)

At regular intervals (to establish a normal baseline) and whenever either a shift (increase or decrease) of G is sensed, or a feature of interest (stylistic or content) is noted, observer should note:

1. Type of evidence for shift
2. Estimate or count of number of students
   (e.g. "only 5 students look at T ... all but 1 looking at T

The signs of G to be observed should include:

1. Gaze direction
2. Postural orientation (e.g. turned sideways, leans forward)
3. Shift of activity (e.g. writing in notebook: stops)
4. Hands raised (give context, T question response? initiates?)
5. General body activity ('restlessness' etc.)
6. General level of talk/noise
7. Number of students talking; (NOTE TOPIC if possible)
   number of students in conversation groups;
   number of conversation groups (as appropriate)
8. Facial expressions (e.g. smiles, concentration, etc.)
9. Audible expressions of affect (e.g. sighs, laughs, groans)

B. Style/Content Features (F)

Observer should try to note occurrence and time of onset and end of periods of teacher or student talk with these features, noting feature type:

1. Personal/Human: mentions self, students, names of real people

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(Feature occurs only if an extended reference is made to the people involved; omit simple use of 'I' 'you' and proper names where persons are not the topic. So omit:"You remember that Joan told us ..." but include "I remember when I was in Viet-Nam I saw ...")

2. Historical

(Other than recent personal history, for which use F1 above)

3. Social

(Topic includes reference to social implications, to practical applications, to current events, to politics, economics, etc.)

4. Fantasy/Mystery/Imagination

(All talk where non-real or implausible or suppositional situations are involved. Scientific hypotheses or simple contrafactuals would not be included unless in some way bizarre or requiring student to imagine an unusual or unfamiliar condition.)

5. Relevance

(Reference, often by way of example or application, to the everyday experience ofthe student. Code both Relevance and Social, if appropriate.)

6. Humor.

(Note as such if humor was likely intended, or talk was interpreted as humorous, or both)

7. Terse/Expanded

(Note when 'the same thing' has been said in a concise, normal scientific form and is then expanded or explained, or if expanded forms occur at all where a terse form may be presupposed.)

8. Formal/Colloquial

(Note when talk seems very colloquial and informal in register, or when formality degree suddenly shifts, up or down)

9. Non-science topic

(Note when reference is made to a topic domain outside of science as part of talk about science. Exclude 'administrative' talk, but include domain of 'the school' if referred to. If a feature listed above is a special case of this feature, do not note both.)

10. Memorable talk/ Bizarre, or Emotionally-loaded

(Note locutions or examples that seem especially 'memorable.' A well-turned phrase, a bizarre example or an emotionally loaded one.)

C. Critical Events

Note events that may mark or determine situation structure or change:

1. Event, including talk, that marks episode boundary

(Episodes may be major structural units, e.g. the shift from preliminary business to the main topic of the day, or finer grained units, as in the shift from an explication to questioning, or even from general questioning to intensive pursuit of a particular theme through questioning, to a sequence of questions with one student on that theme.)

2. Trigger events

(Note events/talk that seem to trigger multiple or intense response events. E.g. a statement by T that triggers several student initiated questinns.)

3. Interruptions

(Note the occurrence and the effect of interruptions, esp. those with causes outside the system of actions of the participants, e.g. a bell, a late student entering, a P.A. announcement, a visitor, etc. Note also events originating within the class that interrupt or divert the course of subsequent action: e.g. student fight, student leaves class, etc.)

D. Special Non-Audio information

1. Teacher non-verbal behavior, including:

   a. Location change (indicate from-to positions, path, rate, etc.)
   b. Major posture/ posture shift
   c. Gaze direction pattern
   d. Facial expression
   e. Object manipulation
   f. Prominent displays (e.g. gesturing)

2. Contexts for indexical speech

   a. Deictic referents (e.g. points to, say "this or that?""you")
   b. Blackboard writing, diagrams (only when relevant)
   c. Other written materials (texts, sheets) and aids (charts, model
   d. Other situational contextualizing features

E. Dimensions of Situation

1. Group organization structure
   (Note subgroups in the class and their changing configurations)

2. Observer's comments on nature of situation, shifts of situation

II. General background information

NOTE: The observation team will also obtain information about the teacher, the class, on-going circumstances of relevance, the school, etc. These are detailed on another protocol.

The team will also record the physical setting of the class, locations of observers and recorder mikes, etc. as described in a separate protocol.

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School of Education

FALL 1979

NSF PROJECT: Classroom Communication of Science

PRELIMINARY NOTES ON OBSERVATION PROTOCOLS

J. L. Lemke

PART II. Background Data

A. The Teacher

1. Name (Confidential: not on Fieldnotes or Tapes/Transcripts, CODE)
2. Age/Sex
3. Academic history: Colleges/Majors, Dates
   Most recent college science course
4. Teaching history: Subjects and grades taught
   Years of experience (each level, total)
5. Other: Knowledge of project at time of observations
   Prior contact with investigators
   Courses in teaching methods ? where ? when ?

B. The School

1. Senior or Junior HS
2. Size, condition of plant, age
3. Location
4. Student body: geographical, diversity
5. Special considerations

C. The Class

1. Number attending, total register or ave. daily attendance
2. M/F
3. Curriculum/ selection criteria for students?/ Ages
4. Student diversity: ns or ratios
5. Evident subgroups (interacting)
6. General activity level: vocal, motor
7. Estimate of observer effect: by T, by Os

D. The Room

1. Diagram of layout: doors, windows, boards, desks, apparatus
2. Location of observers, assistant, recorders
3. Special conditions (climate, crowding

E. The Lesson

1. Topic
2. Context of prior/subsequent work; tests?; term, cycle, etc. ?

NSF-CLASSROOM COMMUNICATION OF SCIENCE

J. L. Lemke

Notes on Revisions of Protocols and Criteria
(November 1979)

A. Communicative Engagement (G)

Total engagement with the lesson, G, is a characteristic of the class group as a whole at any one time. Individual Ss may be hearing what T or other Ss are saying, and mentally responding, but not looking at T or another S who 'has the floor.'

Estimates of G should be based on the total of at least the following:

1. Gaze to T (GaT)

2. Gaze to Board (GaB), when there is material on the board which students are expected to copy into their notes, or when there is material on the board which is relevant to current topic focus of the group's discussion or activity

3. Writing in notebooks (Nbks), when copying material newly placed on the board by the teacher (or other student), usually accompanied by GaB.

Indicate GaB-Nbks when the ususal looking-and-copying is occurring, otherwise indicate just GaB or just Nbks.

(Magnitude of effect may be indicated as % of class in each category, or total # of Ss in each category.)

4. Side conversations on topic (Sides-On), when observer has evidence that Ss engaging each other in sides are actually discussing or commenting on a topic of the lesson.

This is a difficult behavior to judge in relation to overall group-engagement. Observer should simply note it as a separate category. In analysis we may find that sometimes these sides contribute to an overall group communication pattern on the lessons' topics, but in other situations they may isolate the side groups from the dominant or majority interaction pattern, even though they are on topic. The presumption is that if they occur simultaneously with utterances by T addressed to whole group, that they are (-G).

Otherwise G is to be estimated as in the original protocol (FALL 1979).

B. New Category: Instructional strategies

Some actions and uses of speech by T may be more easily classified under an instructional strategy than as stylistic features, though these sets of categories may overlap.

-cont.

B. cont.

Some common strategies (we must add to this list):

1. Mystery - T is trying to build a mystery, to make the familiar strange, or the obvious problematic. Usually a series of questions, with an intonation pattern of doubt or wonder or skepticism, often taking student answers and turning them around into further questions. "How could this be?"

2. Co-optations - T is trying to create a sense of group solidarity, to redefine a situation of T-and-the-problem vs. the students to be one of T-and-the -students vs. the problem. Use of first person, esp. plural pronouns. Off-hand linkage of S name into statement or question.

3. Meta-processes of inquiry - T is talking about the general strategy he or the group is using or will use, about the way words or terms are used, about the processes of learning and study.

3a. Processes of science - same as (3), but T refers specifically to science and its processes, e.g. experimentation.

C. Revision of Stylistic Feature categories

Category F3 'Social and F5 'Relevance' are to be subsumed under a single general category: RELEVANCE, which must now be marked by observer as of one of two types:

Relevance-societal: broad social implications, current events, economics, politics, applications of science spoken of in relation to their broad societal importance

Relevance-Everyday life: connection made to events, objects, phenomena in the everyday life of students, frequently manifest in choice of examples. Applications as they affect our everyday lives rather than in terms of wider social impact.

JLL

II. The Nature of the Data Base

Fieldnotes by one or more observers and audio- and or video-tape records were made in 61 lessons, taught by a total of 20 different instructors, in 4 institutions (one Junior High, two Senior Highs, and one University College).

Co-operation from chairpersons, teachers, colleagues, supervisors, and others was excellent. Of all teachers who were approached, even tentatively, only one declined to be observed. This high degree of co-operation results in part from close relationships between science departments and the Brooklyn College School of Education built up over past years.

Documentation exists in the project files on the institutions, departments, instructors, student population, observers, curricular context, and special circumstances of each lesson observed.

In a typical observation, the principal investigator and his technical assistant, and in many cases also a consultant or second professional observer, conferred briefly with the instructor before the start of the period concerning the project (usually discussed before), the nature of the lesson and the class. Entering with or before most of the students, the visitors sat at the sides of the room (rarely in the rear), with one recorder front and one at rear. With a good view of students as well as the instructor, fieldnotes are made on nonverbal signs of communicative engagement, on side-conversations, relevant visual information needed to contextualize and interpret the audiorecord, and descriptions of classroom events, all indexed by real time with brief notes of simultaneous teacher speech for synchronization. When videotaping, the camera usually panned across the students without closeups, and was situated in the front of the room. The visitors presence was usually referred to briefly by the instructor with a very vague explanation of our purposes. All classes were visited at least twice, most three times, and some as many as five times. Students, except a few individuals, generally attended to the lesson and ignored the visitors, except in the presenceof the videocamera, which either inhibited behavior (for older students) or invited "mugging" (younger students).

Nine reels of videotape were made, the minimum to permit checking of observer reliability under a variety of conditions. The principal of the Junior High School asked us not to videotape. One scheduled high school videotaping was cancelled because of the unexpected absence of the teacher on one of the last days of project data collection and a college class was substituted. The videorecord is adequate for the purposes for which it was intended, but it is not I believe the methodology of choice for a project such as this. Only when a single or very small number of classes are being recorded over long periods of time, I think, are the advantages of video significant. Studio-like conditions are really needed. The analysis of the visual information in a videorecord also lags far behind the technology to record such information, especially in comparison with what we know about linguistic and paralinguistic analysis, little as that may actually be.

The database incorporates the diversity needed for comparative analysis. Instructors range from those with 2 to those with more than 20 years' teaching experience. Only two female instructors were included, and a plan to deliberately add more women teachers to the sample was dropped because by the time it seemed necessary to do so, the projected size of the total sample was already larger than could reasonably be analyzed. No minority group teachers are included, though many classes have large numbers of students across all the socioeconomic and ethnic and racial categories of New York City. At some future time, when we know what this project should tell us about science communication, we can use that that information as a baseline for comparative studies across these categories and between men and women science teachers. My own guess is that it is the students' categorization rather than the teachers', or possibly their matchings and mismatchings, that are associated with different communications patterns.

Classes were observed in Biology (25), Physics (17), Chemistry (8), Earth Sciences and Astronomy (11), and in one case two social studies classes taught by a teacher who had also been observed teaching his primary discipline, Biology. Of the Main Observations (not counting preliminary or follow-up visits) 24 were made in a senior high school (grades 9-12) setting, 14 in the college setting, and 6 in the junior high school (grades 7 - 9). In the senior high school, classes were observed at the 9th grade level following the junior high school curriculum (or one closely equivalent). College classes of formal lecture format were supplemented by small class sessions more comparable to secondary school classes. Formal lectures did not provide much data on patterns of communicative engagement relevant to the secondary schools, but they do provide an essential basis for characterizing the norms of standard scientific communication in the teaching situation.

16 lessons were co-observed by the principal consultant, Professor Shirley Brice Heath (then of University of Pennsylvania, now at the School of Education, Stanford University), whose enthusiasm for the project and whose excellent skills and insight as sociolinguist, educational ethnographer, and student of classroom language were an outstanding asset to the project. A draft of her comments on our work together is appended to this report (unedited). An additional 6 lessons were co-observed by Professor Harriette Kaley of CUNY-Brooklyn, whose interest in the relations between the affective and cognitive dimensions of classroom processes is not a part of this project, but whose notes on the classes and insights will certainly contribute to its success in important ways, and Professor Roy MacLeod of London University, my prospective host during the parts of Year II when I will be consulting with British experts in the analysis of classroom language and interaction (see below).

In addition to classroom observations, the database contains episodes in which an instructor is working with a student in a one-on-one setting, often after the end of the period. It contains interviews, some recorded in their entirety between the observers and the instructors, separately or in the context of the review of a recording, and with students, both participants in the class observed and non-participants with similar backgrounds. Some college lab and problem sessions (without actual labwork) were also formally observed. One graduate class of my own was recorded discussing features of a tape of a high school class similar to ones they teach. Specific uses were in mind for each of these kinds of supplementary data (see below).

TRANSCRIPTS

DRS: Lesson DRS-6-2s (27 November 1979)
Fieldnotes (JLL)
Fieldnotes (SBH)
Transcript (40 minutes)

JR: Lesson JR-5-2s (29 October 1979)
Transcript (15 minute episode: The Giant Cell)

EL: Lesson EL-8-2 (20 November 1979)
Transcript (19 minute episode: Longitudinal Waves)

LG: Lesson LG-5-1s (26 November 1979)
Transcript (26 minute Main Lesson: Terrestrial Radiation)

SC: Lesson SC-5-2 (11 minute episode: Fossils and Crustal Movement)
Transcript (20 March 1980)

KF: Lesson KF-4-1m (15 April 1980)
Transcript (13 minute episode: Oxidizing/Reducing Agents)

Transcription Conventions:

Citation: DRS 6L12 is line 12 of page 6 of transcript DRS
11:13:45 is time of utterance in untranscribed discourse

Speakers: Teacher is the speaker unless otherwise shown
Na: is student named in the text
SM, SF: unnamed male, female student (SM': another student)

Dialog: Where two speakers alternate or overlap, the lines of transcript are read like two voices on a musical stave, with the symbol / placed above and below in each parallel line. These lines would be joined by a brace in the margin in other systems of transcription. Each speaker's line continues below on the page in the same vertical order. Where there is a possible ambiguity, T: or another identifier appears in the margin to designate who is speaking that line.

Symbols: ((...)) enclose analyst's note of nonverbal information

(   ) with blank interior is speech not resolved
(something) is probably resolution of speech

. is used for minimal pause or hesitation
.. is used for double minimal pause
... is used for pause of one to two seconds
(5 sec) gives time in seconds of longer pauses

. Followed by a capitalized word other than proper name is used for end of tone and breath group with declarative intonation
? same with rising, questioning intonation
! same with exclamatory intonation

something shows stress emphasis

= links segments pronounced as if one word
- marks a sudden breaking off of the prosodic contour
'something' enclosed material is annotated in margin

DB indicates a loud bang of closing door, used for synchronization

DRS

27 NOV 79 Period 6

MAD/ Chemistry

Main2

FIELDNOTES: Madison HS: Honors Chemistry Period 6

Teacher: Dr.S: male mid 30s. 10yrs total teaching experience, including: 4 yrs in JHS, 3 years in a remedial program in a community college, and 3 years SHS chemistry. Has an Ed.D. in science education, and MS in organic chemistry. Last science course taken was in 1970.

Class: same as 26 Nov (=Main1). Students all 11th grade. 27 present today, including 17 women, 4 blacks, 3 orientals, and one indeterminate (hispanic?).

Topic: Electron configurations and chemical properties, II (Halogens) "Chemical periodicity"

Conditions: JL and SBH present. R. Jencks subbing for RD on second recorder (see endnotes), also took a few notes (see 27 NOV (5)).

12:02:58 Front recorder start/ live at 12:03:03

12:03:27 One bell has rung. Ss coming in. T and S at bd discuss a diagram. Class very noisy; a large girl is play-fighting. T and S still at bd, talking about electron motion (T making some conceptual errors in what I overhear). The diagram is left over from an earlier class, showing orbitals in colored chalk on front bd.

4 46 T has written "Lesson 42: Chemical periodicity"

5 24 T asks review questions about diagram. All Ss are sitting quietly with notebooks open. Some Ss are copying digram. Gaze to T and Bd at
6 13 -- is all but 6 students. The door is open, there is a cold cross draft.
Or girl answers 'Carbon' very quietly, (omega?)

ue 53 8 24 DB, soft. Follows 'ok was page 69...OK...'
Ss have been taking out HWKS
T asks/reads question '7...a' 4 hands up. T is at demo with his book on the table. Makes concept error in saying that electron cannot be in the nucleus. Cheryle (C) reads from her HWK, sounds copied from book, long and technical with formal register. (C is blk fem.)

10 53 T going over Qs with Ss, calling one for each. T is reading the qs, deliberate voice. 1 side of H and A.

1 43 SQ. S asks 'like this' mimes. T draws on bd.
54 S' raises further issue. T turns own body around to indicate spin of electron. Gaze tohim increases, but only briefly.

2 26 T having some trouble eliciting (password) on electromagnetic relation. First does one way, then reciprocal.
50 T explaining spin magnetic effect, gets gaze increase.

13 18 'how Einstein made his fortune' Laughter. Ts gesture explantions have been imitated by Ss to some extent, especially in the discussion of clockwiseness. Now an S asks/mimes if T can do kids trick of patting one's

12:13:18 (cont.) head while rubbing the stomach in a circular motion. T says he can and vaguely moves hands to do so, also turning body away to bd. In this exchange gaze to T and general engagement have noticeably increased, from the gesture question on c-clockwise to now. After laughter on 'pat your head' T asks if S can 'describe in words' which gets more laughter because of the implicit contrast to description by these amusing gestures. (There is some norm enforcement here.)

Jeff (H) says ' 3 dimensional'. He came in late and has been eating in class.

4 08 T describes 3-D p-orbitals as fat, then fat (here) and skinny (there). S says 'that's nice and scientific A moment later T picks up and repeats this phrase. (This is an important example of Ss enforcing, or at least showing that they know a norm-violation has occurred. Is this only true in such a sophisticated honors class, or also elsewhere??) (Note also that Ss must feel fairly confident and trust T in this class to say such things openly.)

'schools with better budgets' Ss comment.

4 54 T uses fingers ('this way') to illustrate orthogonality, two hands fingers interlaced. Laughter.

5 17 Typical gaze to T if T talking during these exchanges is only 2 or 3 Ss, most look to their papers.

6 00 SQs. "Why do they ask why?' S who answers is sigma. When T mentions 'Hund's rule' and explains gaze to T comes up to 50%.

7 05 Back to same gaze pattern as above. Few students tend to reorient to an S if that S is having trouble answering the question (supportive? competeive?)

7 51 Mario answers in formal written style, but makes grammatical error. T shifts to s'= Cheryle for restate, T gives a more informal discussion of energy, uses very broad gestures as says 'electrons fall back', then as he repeats in other words for question, he uses his head to nod in a similar pattern to his arm gestures. He gets increased gaze and general engagement at this point and 4 hands up for the 'photon' question.

8 53 T mentions test on Friday, that there will be review tomorrow. Ss pass their HWK papers forward. T writes at bd.

9 21 'Try problem 22' T collects papers across front row. T gets chalk to do #1 of HWK. Class siding quietly. (#1 = problem 22)

20 40 2 Ss ask why T is doing their HWK in class. Ss copy table he puts up. Ss disoriented, ask each other what's going on. (They do not understand why T is doing a HWK problem. His prior explanation was very brief and not caught by most of them. They wonder if he is making an error, or if they have misunderstood the assignment. Some seem confused about where in their notes this belongs. Evident from sides' content.)

12:21:26 T looks at his book. Has put up chart on bd, to be filled in with answers. Ss echo 'electron dot' with serious, low-pitch inflection.

2 20 Ss go to tables. Overall there has been little long protracted or distracting siding in this period.

3 17 Ss orient to Frank as he anwers, he seems to be in trouble (cf. above) 3 hands are up while T engages him. T clears up confusions. Has frequent trouble with S names.

4 12 T fills in chart on bd at door end of front bd, Ss on JL side of room orient posture to him.

4 44 Gaze to Bd rises to 60%. He calls on Jennifer C.

5 12 ' book does' Note locution, cf. 'they'

5 34 'OK' T was about to start new lessonmaterial, but SQ says she doesn't understand...

6 21 T near JL. 75% copying from bd.
T starts metaphor of electron going to cheap hotel
There is now confusion over conventional numbering of levels in relation to energy. Cheryle's question. T speaks of put together by 'printer' 'by chemist' How he personally thinks of it. But he has missed the more proper explanation interms of atomic number or atomic mass.

9 00 'next year' T will tell them about higher shells (Means next term or next year in AP chem?)

30 T is holding small table, pointing to it as explains, also refers to wall table chart. Gaze to T at
30 03 -- increases to all but 1 (who is Mr. H)

49 T doing numerical in answer to SQ about n^2. Sigma copies, also a few others.

1 18 Real lesson starts. T asks for Cl, Br, I.

S near me says she can't find Cl on table (1), gets help from omega (or fem). S in trouble is 'g'/.

2 18 T looks at S paper. Class working very quietly, no sides. S asks for Table, T regards him in mock horror (that he does not have one with him), gives him one. 'h'tries to side, does not succeed in engaging intended partner. H is off task focus, looking to JL. He has a nonverbal side, then talks with female, K.

4 15 'Let's try' SQ 'about dots'

58 Carl anwers in symbols. H hand up to answer Br. Looks at his paper to check himself.

5 39 S challenges T's consistency (Cheryle?) T says both correct. Joking comparison to free variant in pronunciation of iodine. H answers for Iodine.

6 47 Ss comment as T goes through answer. Ron asks SQ. H asks SQ ' why do we do this' (NOTE use of coptative we) T says 'like to have opposite spins' Ss comment on his use of'like' (ANother norm-recognizing/enforcing by Ss, here of the violation on like, cf. Hiz p. 40)

12:36:47 (cOnt.)
T intervenes in the side of omega and 'g' (who are Jennifer - not Jennifer C. - and Joan, resp.), who has again been getting help from her. T is concerned only that Joan is getting the info she needs. Asks her Q.

8 24 H holds up his hand. He is Jeff (H): 'getting a pattern'

9 06 Engagement up as class chorus generalizes on pattern, laughs. SQs about B elements. T speaks of 'Bs", S jokes they are the killer Bees. T accepts joke. (Joseph made the joke. He is Mr. C of B and C. B is Carl)

T refers to chart. Asks orbital for transition elements. There are no hands raised. Natalie (nu) get it right.

40 43 T puts up stand on demo table. Ss ask/comment ' gold?' (I.e. has he really got gold in class?)

T puts out Cl, Br, I, but says Cu, Ag, Au as a cue to disattend demo just them.

1 28 T washes hands, has just handled halogen bottles. The period of hi engagement is over, but still relatively high.

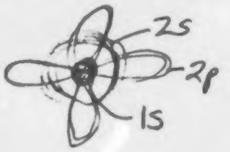
'free in nature' Class jokes on 'free'.

12: 42:20 ' not true' that it's free. S fingers his gold ring.

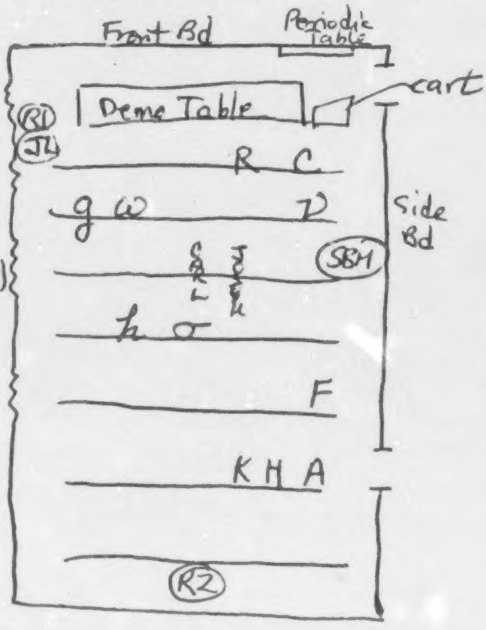
12: 42:36 Bell. T and Ss groan, disappointed not to see demo. T hold the class, Ss say they are willimg to stay. Then they put notebooks away as they ask 'that it?' Class leaves in no great hury.

12:43:12 Front recorder off.

Diagram (opening of period)



R=RON
C=Cheryle
ν=Natalie
g=Joan
ω=Jennifer(ω)
H=Jeff
σ=Sam
F=Frank



Sign near door:

JOIN OUR
ASIAN CLUB
...

See RJencks notes
attached to 27NOV(5)

DRS (SBH)

November 27, 1979
Madison High School
Period 6

Mimic tone?

mini-episode 12:05 Many Ss throwing items, much stirring around. T atboard with 1 S, giving explanation of problem. T: "Before we get started..."
T shows diagram on board.
-T calls on Jennifer C. only 40% of class attend. Rest are involved in class socializing, getting out materials. Central axis of two Hispanic boys exchange items, give no att. to T.

12:06 -mention of 2 p again calls up laughter and word play by class. T calls on Ron, who gives wrong answer. L girl answer, and T explains. Much outside noise during this period. Ss begin to copy. 60% G. T says "it's
end of mini-episode/from the other class..."

12:08 T comment on tutoring, 80% G, several wait, some write. T instructs class to take out homeowkr. Latecomer enters.
Ss comment on "what is homework?"

episode begins- -T reads roll. 60% G to notebooks, 20 to T and 20 to answer-giver, for T Q.

Homework is focus. 12:10 T expands on S answer, then reads from board. Calls on Janice.
Boy from central axis answers, and T says "your name Jamice?" Much laughter. Sheila reads. 80% G to their own answers, except one member of central axis.

12:11 T expands on answer. T reads. S help direct him. Central axis answers out of turn again, this time for Jackie. T asks Joseph of central axis. He answers without looking at notes. Several sides on in back of room. Several Ss comment and call T attention to something which was skipped.
-T says "thank you" at end of each correct answer. As T asks Q's, he does so very emphatically, asks Q, waits for answer, says "thank you" then moves on.
-one partner of central axis Hispanic pair is confused, asks Q, Several Ss ans, and T demonstrates with his body. 45% G. Rest attend to notes.

12:12 T comments on kind of field, asks Q, then calls attention to their needing to remember it from Gen. Sci. Teacher says "let me phrase the question conversely...." 85% G. T looks at S moveing hands. Ss

meta-process and T exchange comments on process, as Ss try to move their hands counter clockwise, etc. Pat stomach and rub head, etc. Laughter.

12:13 T talks about problem, including defintion of infinity. Calls on

meta-process science Mark, Jeff, Uses imaginative language, 85% G and some laughter. S comments as T says "fat and skinny" that this is nice and scientific.
-when T asks questions, he over-emphasizes its parts. T reads with

12:14 attempt to demonstrate with his fingers. Draws on board. Many laugh quietly.

(Both teacher and students seem to recognize that this kind of drill is necessary, and they move through it with ritual emphasis.)

T calls on Nathalie, gives wrong ans, T and Nathalie in dialogue. Several Ss attend to dialogue, others die or look at notes.
Ss asks question. T asks another S to answer. 85% G.
-T calls on Ron, some Ss write.

12:15 T reads Q and name, S answers "I don't know." T continues process, and G to other Ss drops, as most Ss attend their own homeowrk. T asks for ways of saying answer different ways, comments on need to understand "what

metaprocess you're saying." Calls on Nathalie.

mini-episode -T asks for papers to be passed forward, mimics grade school rule.

12:19 T writes on board. Ss give 85% att. to board. T is writing homework, and several comment that it doesn't fit usual pattern. T says homework 11 to be checked. T says "let me do the first one..." T erases board.

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Madison High School
Period 6
Heath
page 2

T talks about the fact that homeowrk is table to be filled out; several Ss ask why he is doing it, can't understand if it is indeed homework. Ss comment to each other. Some copy. T writes on board. S from side wasks specific question to T as he writes. Some Ss say ditto. Some question way he has written something, and he explains there are 3 different ways of writing...."

12:21 T asks Ss to get out periodic table. T calls on central axis. T en Frank. 100% G divided between T and charts. T induces mystery by tone.

me Mystery
-T points out electron dot is only outside shell, T pauses, Ss nod to show they have understood the mystery.

12:25 "Okay,..." T explains something from book. Ss question. (why?
"Okay, do I have all the homework papers..." Nathalie asks Q, T demonstrates answer on board. 85% G. T-Nathalie dialogue. T asks Q with mimic tone. Several Ss side on topic.

12:26 T comments on "cheapest hotel."

memorable language
-movest from lowest to next lowest. S answers, but T asks why, and S says "I don't know." T moves through steps---next lowest, etc.
-exchange on mother nature, sides on Father nature--from central axis. T trying to explain discrepancy between chart and what is on board, Ss confused and want to know why. T can't explain to their satisfaction. T moves through explanation again and tries to check to see if Ss understand. "Nest year..." T induces mystery about what they'll learn next year, then next week. Ss questions and T dialogue with Ss on their specific questions.

12:29 T goes on asking questions, following line of S question. 85% G. T offers "okay" as though to begin lesson, and S asks Q again.

12:30 90% G as T explains S Q on board. T. "Where was I?" Number 2 and t calls S att. to this. Ss use charts--T and class giggle over pronunciation of iodine. T puts platform on desk. 100% G to their notebooks, write and work problem. T at side looks at Nathalie's work. T says "You can abbreviate.." Natalie responds that she wants to practice. S in back has no chart. T xxxxx mocks horror. S comes forward for chart. Central axis of Hispanic students exchange Side on topic. T whistles, while Ss do problem, some join in. Central axis is worried about dots discussed earlier in class. T waits. S asks about dots...one Hispanic gives answer and grins at partner. T responds "good."
-As T works into problem, S who had asked question about order of writing earlier, comments that T is now doing it differently than he had earlier explained. Jeff reads answer. 100% G as T talks about outsdie sheal. Ron asks Q about where dots should be put. T answers again. Much rumbling by Ss on topic. (Placement of dots is still a matter of much concern for class; explanations have not settled the matter for Ss.)

12:37 T calls class down. S G up to 80% some write, several Ss have gotten answer. Students comment on humorous language, actually remind T of

metaprocess norms of science language. T ignores this comment on process by Ss.
-T explains ans. to one S, 85% G to T or notebooks. T offers side girl help, gets another S involved in helping her.

12:38 Jeff from back of room says "Im getting a pattern." T: "What is the pattern?"

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Madison High School
Period 6
Heath
page 3

T asks this in mimic tone, and class acts like chorus--"isn't that amazing" comment runs through class. 100% G to T and board. Many Ss comments on process.

12:40 "The B's have a special name/..." Other Ss comment "killer Bees.." laughter--100% G to notebooks and T. Door opens, T closes it. 100% G to notes, and T sets up experiment. T asks "What do you notice."

student-initiated humorous language

12:41 Ss answer, and T asks meaning of answer. Carl from central axis comments that all have one dot. Nathalie calls out"But you forgot..." T goes through routine, again in mimic tone. As T comments on "free", one partner of central axis comments on irony of free (word play).

12:42 Bell, T groans, but calls out "Wait." Ron and T chat, Ss answer question. Some Ss groan also, but T calls out questions and Ss ans. in chorus.

This class seems to have no central episode, or even discernible mini-episodes, because Ss take over class with their questions. Lesson becomes joint effort, but one directed by Ss. Teacher's attempt to start experiment, to redirect discussion is not respected by Ss who feel it more important to have critical questions answered. They enforce norm of their doing homework, their understanding process, and their being clear on conventions of notation.

27 NOV 79 Per.6 FIRST LEVEL TRANSCRIPTION

Chem/Main2

12:03:03 ((Recorder live))

((T at board talking to S. Many Ss talking))

((SM$_1$ making loud verbal display in hypertense, artificial voice))

Yeah.. aw right. that's. see that doesn't ( ) ((T to S at board; other Ss talk continues))

((SM$_1$ again in artificial voice))

New entrant SM$_2$: Eyy::! ((Some delayed echoes by other Ss))

'Fighting' SF: Oww::! ((mock scream))

((T and S still at board, Sm$_1$ in artificial voice, SF play fight, and general Ss talk continue in complex texture))

((Slight lull, then sound of two male Ss talk))

SM$_{2?}$: Eh-y! ((Slight lull, SM$_1$ again, lull into which T:))

---------- 12:04:46 Before we get started... before I erase the board...

Ss: Sh::!

soft (miss) Uh... Look how fancy I got ( ) ...

((SM$_1$ in artificial voice))

Ss: Sh:!

This is a. representation. of the. one. S... (2 sec) orbital

S'pozed to be of course. three dimensional... (3 sec)

What two elements. could be represented by such a. diagram?

(1 sec) Jennifer?

Je: Hydrogen and helium?

Hydrogen and helium. Hydrogen would have. one electron...

somewhere in there.. and. helium would have.?

SM: Two electrons.

Two. (25sec) This. is..one S.. and.. the white would be..

Mark?

M: Two S. ((crash))
Nom tone T: Two S. And the green. would be /.. uh: ../ Janice.
/Ja: 2P /Ja: 2P
soft Ja: (Two/P)
/Two P. Yeah the green would be 2P.x and 2P. y . If I have
one electron in the 2Px. one electron in the 2Py... 2
electrons in the 2S.. 2 electrons in the 1S.what element
chalk squeak? is being represented. by this. configuration...? ((High
pitch sound)) - Oo:! That sound annoys, doesn't it? - ((Laughs))
Ron?
Ron: Boron?
That would be. that'd have uh.. seven electrons. so you'd
have to have, one here.. one here.. one here.. one here.. one here
./. One here. Who said (it).. you? / /What's...
SM_1 artif. voice /SF: Carbon /SM_1:( ) /SM: ( )
/ Carbon. Carbon. Here. Six electrons.
/SM: Carbon
((DB)) And they can be anywhere within those.. confining..
orbitals. This is also from the notes from before. The
transversed(sic) term orbital refers to the average region. transversed by
an electron. Electrons occupy orbitals that may differ
in size.. shape.. or space. orientation. That's. that's from
the other class. we might as well use it for review.
((T pause 6 sec. Ss talk))
CUE 43/25 12:07:23 Tutoring. with Miss Kitchener../Thursday..
/SM: Tutoring with who?
Period 3/ Miss Kitchener. / Nice? / Uh:. She help you?/
/SF:( ) ?SF':( ) /SF:Yeah. /SM:Ye
Good. (2 sec) Tutoring with Mr. Forbes.. Wednesday and
Thursday. period. 2 . (5 sec Tpause)

Cu 46/A -----12:07:47 Please take out your.homework. homework. 10.../

/SM:( ) SM':( )

SM: Sure it's number 10?

SF: ( ) it's s'posed to be. number ( ) 10 ( ) we had two homeworks in between...

But I didn't collect them / I didn't collect those

/SM: 15

two homeworks. So... (7 sec Tpause) O.K. it was page 69.

SM: Tells us right away . 15! / ( )

T / It was homework 15? ((Laughs)

'reads' O.K. (7 sec) Question number 7...a. 'What-is-an-electron-

12) cloud?' Sheldon?

'mispron' Sh: The portion of space about a 'nucleus' in which the electrons may most probably be found. ((Reads from his HWK))

Fine. These are kind of. representational diagrams. of electron cloud. theory. Of course. that's like most of the time. Sheldon said... If you uh.. 99 % of the time. Theoretically it can be anywhere. except in the nucleus. Electron can exist anywhere in space. exccept the nucleus.

20) (3 sec) OK.. number. letter B ... What properties does the electron cloud give an atom..Janice?

Ja: 'Gives it / size and shape.

/SM: Shape and size.

Your name Janice?.. Is your name Janice?

25) SM: No./

/SM': It is!

Ja: Size and shape.

Size and shape. Thank you. Also spat' orientation. a little

gesture bit? whether it's . uh . going this way.. or (that)

((trails off)) (2 sec pause)

Cue 65/47 12:09:38 OK. Question number 8. 'What are the 4 kinds of quantum
numbers. and what does each indicate'.Cheryl?
Ch: 'The principal quantum number. which indicates the most
probable distance of the electron from the nucleus.. of
the atom.. the orbital quantum number. which indicates the
⇒ 2 lines of TR omitted
position about the z-axis. in space of the orbital. and
the spin quantum number which indicates the property of
the electron spin orbital (   ) the nucleus.' ((Rd own HWK))
T: OK. The spin quantum number being.. that it's either spinning
clockwise. or counterclockwise. Each.. if this one's
spinning clockwise. the next one would have to spin ./
counterclockwise.
/Ch: counterclockwise
OK.. then I asked for number../ nine. shape of an
/SM: 9
S orbital. Jackie.
S: Sphere/
/Ja: Sphere ((T and many Ss laugh. Ss comment.))
rising tone' Thank'you'.. Sphere. Ah.. Joseph./
/SM: ((laughs)) Who's that?
How many S orbitals can there be in any energy level?
Jo: One
One in the.. K. one in the L. one in the ... Fine.
"How many electrons can occupy such an orbital'. Carey?
Ca: Two
Thank you./ 'What is the lowest energy
/SM: Two ((laughs))
level having an S orbital'.. Josephine?
Jo: (I didn't get it.)
Well. think/ a ...

4:30) Well. think/ a

1) /SF: You skipped one / /Yeah!

/SM: You skipped one

/S: Sh!

SF: You skipped D

'What characteristics must these electrons have?' Ron?

Ron: Must be spinning in opposite directions

/Right. .. Now I'm

going to ask Josephine this question. 'Which is the lowest energy level having an S orbital?'

10) Jo: (5 sec) The uh. you mean the shell?/ K./

/Yes. /Thank you.

Cue86/68 12:11:41 SM_q: Uh.. what's the/ /Spinning what?/

/Level number one/ / One

must be spinning. one direction. the other one spinning the

other direction./

/SM_q: Yeah. but then you go like this...

SM_q: Right?/

/ They're going like this.. (2 sec) You know. just

Bk recorder feedback like ((high pitch sound)).. just like the earth.. the earth

20) is rotating on its axis. and its going around. the/

Planet

/SM: Earth

in an orbit. Same thing. And what happens.. Who can tell me what happens. if a. magnet.. ss.'scuse me. if an electrical... property. spins? If you have electrons

25) spiming? you'd get... what kind of field? Anybody remember that from General Science? (2sec) Let me phrase the question.. conversely... If you have... a magnet.. ~~xpinx~~ spinning around a coil of wire.. what do you get. Frank?

Fr: Like (eliction) ?/

1) / Electricity. Yes. And if you have. electrons.
spinning. you get a magnetic field.. So that that's whay.
if they spin clockwise you get one kind of magnetic field..
if they spin counterclockwise. you get a different kind of
'soft' magnetic field... and. uh. that's why you.'you (   )
magnetic quantum numbers.' ((T and Ss laugh))
Which=which way is this. clockwise or counterclockwise?

SF: According to it/
/SM: Depends on who you-/
10) /SF':/To us
/SM: To us-
SF'; its counterclockwise. but to you it's clockwise.
Cue
102/84) 12:13:14 T: Relativity! That's how Einstein made his fortune.

SF: Well. can you do that-? ((Ss laugh))/
/Can I tap my head
an. no. I can't do that... Yeah.. Yes. (he? I?) can.
C'mon... We were on ((laughs)) ... We were on 10. 'The shape of a
P orbital.' ( )urely. Who can describe that in words.
((SF laughs. T laughs.))
Max?

20) Ma: Figure 8./
/SF: Sideways.
8 sideways? ., Fi:ne. How about for the.. if it's on the
y-axis. it would be. kind of a skinny 8. or. a. uh../
/SF:infinit
Infinity. Yeah. I think it looks more like infinity myself.
SM: You don't have a name for it?.. but it's 3-dimensional.
Good! Sh! ((to cpmmenting Ss)) You heard. uh. Mark. uh/
/SF:Jeff
Jeff said... (Anyway) ( ) Jeff said it was 3-dimensional..

It's fat. It's uh... fat and skinny. / It's -
/ SF: That's nice
and scientific:/ nice and scientific./
/ Huh? / It is nice and
scientific, yeah.

112/94 12:14:12 SM_q: How about 2S? /
/Two..?/
/ SM: 2S.((Many S comments))
(2 sec) If. If=if. we were... Some schools. with better
budgets. have models... we don't. ((Ss laugh. One mock
groans 'Aw::'))
So you have to use your imagination. (2 sec)
'How many p orbitals can there be in an energy level?'
Christine.
Ch: (2 sec) Three./
/Three.. Thank you... I think I heard 3/
/SM: Yeah.
'How are they arranged with respect to. one.an-other?' Joan.
Jo: Perpendicular? /
/They're perpendicular to one.another.
One this way. one this way.. ((Ss and T laugh)) Orthogonal.
Let's see.. one this way. one this way... and one coming in
and out of the board. (2 sec) ((T sighs)) Heh... 'What is
the lowest energy level having P orbitals?'. Natalie.
Na: P orbitals?/ Uh.. level one.
/Yeah.
Level one only has an S. ((Many Ss comment. T goes 'Sh!'))
Na: Level two./
/Level two. which is the L -( ). OK. You
know why. Natalie?

Na: P only has.. one.S .../ I mean/... *K*.

/*P* only has one S? /*K* has -

K has.. (2 sec) one S... L has... one S. and 3 Ps. (2 sec)

Cue 130/111) 12:15:45 Uh:.. *11*. 'May 2 electrons in the same atom have exactly the same set of four quantum *numbers*?' *Joanne*.

Jo: No./

/Thank you. /

/SM: "why" SM': *Why*? /

/SM_n: No.

SM: Why do they ask why?/

/SM_n: No.

((Laughs)) Why do they ask why? ... Why?/ Sam?

/SMn: No.

Sa: I think it has something to do with the electron spin? .. that they always run. ah. *spin* in opposite directions.

T: 'guttural'

It happens to be called the.'Hund'.rule./

/SM: Uuh! ((disgust))

that.. if.. two electrons. had exactly the same 4 quantum numbers. in an atom.. it would mean. that they were. in the same place. at the same time... And in.reality. two things cannot. be in the same place at the same time. So that. if they were. had the same quantum numbers. that's what they would be. So they have to be.slightly different. (2 sec) OK. Uh... 'May 2 electron's occupy the same *space* orbital in an atom?' uh. *Fran*.

Fr: Yeah/

/*Yeah*. ((Laughs)) 'Under what conditions may they occupy the same space orbital?' (5 sec) Huh? (4 sec) If one's here. what must the other one in the orbital have to be doing? (3 sec) Spinning in opposite directions... *Fine*.

Cue 148/130
12:17:29 And... 12 .. 'Distinguish between an atom in its ground state.. and an. excited. atom"... Mario.

Ma: 'When an atom is in its ground state. its electrons hold the lowest possible energy.. When an atom is in ( ) when. when an atom is excited. it absorbs energy.. Therefore an excited atom holds more energy than an atom at its ground state.

OK.. What you're saying... Anybody else say it differently? You know what you're saying?/ Cheryl?

/Ma: Yeah.../

/SF: I know..

Ch: Um.. the ground state is at a lower energy/

/No added energy.

Yeah?

Ch: and the excited is/

/You add something. like thermal energy.. like heat.. electrons jump to a.nother shell, another kind of higher energy orbit... and. uh.. they're excited. Eventually they fall back. ~~from a higher energy level~~ ~~to the ground state~~ and when they fall back. what happens? Destina.

De: They fall (back)? /

/Yeah. When they fall back from a higher energy level to the ground state. what happens?

De: They. uh. lose energy./

/ They lose energy.. but exactly how much energy? Sam ?

Sa: A photon./

/ A photon. which gives a special characteristic wavelength (to them).

63/144 12:18:48 Pass these forward.. First person hold them.. the teacher will. collect them from the first person.. Cheryl.

Ch: ((inaudiable over rustling papers, other talk))

The test is. Friday .. tomorrow I review. (2 sec)

) Uhh.. (28 sec) ((sound of T writing at board))

Try problem 22.

SM: I think it's homework 11./ Homework

/SF: Homework 11/

/((Tlaughs))

Mcont. that'll stump us.

Some of you have homework. I have homework 11 in my...

SF: It is homework? /

/ Yeah. Homework 11 to be checked..

anyway./ Page 70. Number 22.

5) /SF: page 70?

For the homework...(2 sec) Let me do the first one. for the homework. then you can do the rest... then we'll start the lesson. (28 sec)

22. is a table to fill out./

/SM: Oh boy! ... What.s'he doin'

the homework for us? ((Twriting))

SM: Chem symbol./

/ Chem symbol?/ WHat?

/SF: Why is he doing this?

25) SF: Why're you.../ /SF: Oh-oh

/I'm gonna do the. its. many elements..

I want to explain. to you what the. want.

((Twrites at board)) (22 sec)

Mmm. (23 sec)

SF: Electron dot. is that what.../

1) / Yeah. It says orbital notation.. electron
configuration.. and electron. dot.
SF: /Three different ways of writing it./
/SM: Electrawn Dawt. /SM': Ditto/
/ Yes.
Three different ways. of writing. where the electrons ((dry
throat)). of characterizing where the electrons.are. (2 sec)
Orbital notation. Find sodium on your.. periodic.table.
please. (29 sec) ((T writing at board))
207/188 12:22:38 OK. the electron. configuration. is the one. listed in the
lower left hand corner/..and. so. read me. Carl. what it says.
/SM: Yah.
12) Ca: Uh. Neon 3S1./
/Bracket..Neon..3S1. Any questions about
what the bracket.signifies? Frank. tell us what the bracket
signifies./
/SM: Neon.
Fr: It's like an abbreviation. for .uh. Argon (N's).. it
has. uh. 3S/.. 2. 3P's .../ ( ) It's just
20) /SM: Neon. ( )/ I know,I know...
/Frank?
No=no... Frank F. It's Neon's configuration. not Argon.
Fr: Yeah.. sorry./
/ Yeah. OK.
25) So this means that sodium has. all the electrons that neon
has.. plus. 3S. one electron. The orbital notation.. would
be. that it has all the orbitals that neon has.. plus a .
3S. orbital... And how many electrons in this.3S. Monica?
Mo: Monique./ ... Two./ No. one./
/ Um! Monique. / Two? / One? ..

Take a guess./ One. It's one electron.here.
/SM: One. electron
right. It's one electron. So what do we do to represent
one electron in this orbital notation?/ OK.
/Mo: Put a 3s. one
Or you (just write it.either) way. The electron. dot .. is
another way of notating. electrons. Electron dot is only.
the outside. shell. (2 sec) Only the outside shell. The
outside shell in this one being /.. 3S. or the M.shell.
/Ss: 3S
So the way we do this is we write the symbol. sodium.. How
many electrons in the. outside shell. Jennifer C ?
Je: One./
/One. So then they just put... ((chalk dot sound))
one dot. (4 sec)
OK. The book. describes... uh. on their table 4 - 2.. they
do. period 2 of the periodic table.. we're doing period 3 ..
and we'll discuss this tomorrow. once you have. practice.
SF: All of period 3?/
/Yeah. That's what the.problem asks...
No=actually. no.. it doesn't do the. uh. metals. Oh=no. no.
'soft' trails off no. all period 3. Yes. youre right.'you're right.you're right'
(4 sec) OK. Do I have all the homework papers? ... Cheryl.
43/224 12:25:42 Ch: What I don't understand/ .. I don't understand is why
/ Sh!
do they come this way.. 1S2. 2S2.. 2P..then. um. 2P6./ 3S
/Aw right
(8 sec) ((T writes)) This is energy. (6 sec) What orbital
has the lowest. energy?.. Cheryl./ That's a. that's a
/Ch: K

shell. What orbital has/ The S.. and that would be.
/Ch: S
the lowest one would be. one.. S ... OK? Which one has.
the next.lowest. energy?/ 2S. Which one. has the
5) /Ch: 2S
next. lowest. energy?/ (5 sec) OK?
/Ch: 2P SM: 2P

256/236 12:26:42 Electron comes to town.. wants to go into the cheapest
hotel.../ It goes into the cheapest one that's
/SM: 3S
avalilable. If the 1S is there.. if it's empty.. fine..
if the 2S is there. empty. fine. 2P? great. What's the
next lowest? Josephine? / Thank you.
/Jo: (2 sec) 4S
5) What happened to 4d? /
/Jo: It has less. it has less energy
than.. I mean... I don't know how to explain it./
/ Yes you do.
Jo: It has less energy than 4d. uh. 3 d /
/ Which has less
energy?/ Yes. 4S is. lower energy level than the .. 3d.
/Jo: 4S
Does that answer your question. Cheryl?
Ch: But in here it has the 3d first. (2 sec)/ on the chart-
25) /But-
On the chart it.. because the chart was. put together by a
printer. who likes to go in.numerical order. if it was put
together by a chemist .. or if it was put together by nature
... it would go this way./
/SM: Mother Nature. right?

And I=I. I as=as a mater of fact. when I tend to write these down. and think about 'em. this is the order I think about. And I would write. I'd write down 4S before I'd write down three/ d /   What's after 3d? /

274/255 12:28:06 /SM: What's after 3d?   / SM: 4d

Ch: 4p? SM'': 4s /

/ Look on your charts. After the 3d's are filled... you go to.../   Is that?.what's..a.after...

/SF: 4p

after Zin. Zinc? Then you go to ... 4p. OK? See Zinc is. the next one is. Gallium. Notice that on the chart?/

/Ss: Yes

And then you skip down. after you. fill-up the 4p's... you get to Krypton. or you get to Rubidium... You go to./.,5s. /SF: 5S/ And it jumps down that way. Next year I'll tell you about what happens ^omitted line beyond.. uh. that./

/SM: When does the f come in?

Yeah. The f comes in as a matter of fact.. well. we're gonna talk about that next week. Notice here at the bottom.. Lanthanide.. and.actinide... Those are the. f shells being filled up. The f orbitals being filled up./

/SF: What-tinide?

((laughter)) Lanthanide.. n' the actinide... that's the f.

SM: (What about the bottom?)

The d's being filled up are these transition metals in the middle... all the metals. This's the d's. The f's being fille up are called rare earths. ... and they're over here. Down 't the bottom./   OK?   that's why they're.. (there're) and how many?

/SF: Oh!

There's five, excuse me. there's seven f orbitals .. OK?

How many elements are filling up.the f. orbitals?

... 7 orbitals./ 7 orbitals. How many electrons in each

/SF: 15 ((not to T))

orbital?/ Two. So then 14. How many are there in the

/Ss; Two.

lanthanide series? (6 sec)/ Thank you. ... OK.. and

/SM: 14

in the actinide series.. those're the f's.

304/284 12:30:28 OK. /

/SF: What was that thing with the n squared?

Oh.. that was. if=if n. n is the (principal) quantum number/

:/SF:(and n = el)

then n^2 equals .. if n=1, which is the K, how many possible

orbitals can you have./ ... One. If n=2.. how many

/SF: one

orbitals do you have in the L shell? / Four. one s and

/Ss: 4

three p. n=3 .. one s, 3 p, 5 -/ -d. Very good.

/SF: d

313/293 12:31:06 Where was I ? Chemical periodicity. Number 2. Please.notate.

the ...(3 sec) Chlorine. Bromine.and Io-deen.. Gimme the

electron configuration for Chlorine. Bromine.. and. I-o-deen

SF: Iodeen? SM; I-o-dayn

..or Iodayn/ ((Tpause 14 sec))

/SM: A-ha! ((Laughter by Ss)) SM: Ay-u Dayn ((in

the hypertense, comic voice))

Gimme both the electron configuration and the dot...

((37 sec Tpause. Writing part of this time))

You can abbreviate the uh. inert gas structure/((To SF))

/ Yeah. I

know, but I'm jus' gettin' practice./
/ Fine. Excellent.

inhale, rise tone

(15 sec) Whah? ...'Ahh' ((mock horror)) ... You have one
at home? ... (15 sec) Five orbitals.. that's how many

to SF

electrons? ... 2 electrons per orbital/ Yes.
/SF: Oh. ten.

SF': Would you go over that again?/
(5 sec)/The dots.. the
dots again. (23 sec) ((Whistling)) Whah?/ Dots!
/SM: the dots?
/SM': dots

(Wait on the dots, see if -) (5 sec) Dots are hard. (7 sec)
Whadya put in? 36 dots? / Huh?/
/ SF: Why? I put 5 . I put in 5
dots./ Oh boy! ((laughs))
/ Seven /
/SM: Seven? Ha-ha-ha-ha.
S: ( )/

358/336 12:34:19 /Huh? ... Yeah. All right. Let's try these together.
... Where's my periodic (chart)? Chlorine..shew:: (5 sec)
SM: Is there a special way you have to put in the dots?
Yeah:. I. let's hold off on the dots.. we'll do the dots
together./ I know. You,it gets so confusing in the
/ S: ( )
dots. OK. (5 sec) Carl.

Ca: Neon. uh. 3s2.3p5 / 3s2/ 3p5/
/Neon. then what? /3s2 /3.p.5.
Good. Give me. the electron. configuration for... Bromine.
Natalie./ Brackets.. What's the first one/
/Na: Brackets. A-R /A-R
A-R? .. Argon .. Yeah?/

Na: / 3d10...4s2...4p5
Hmm. Intresting. ... OK. Thank you. .. Jeff./
12:35:30 /Ch: See you
always put 3d first! /
/ That's (alright?because?) I took it
off o' here./ Both are..
/Ch: So which way should we do it?/
correct./ OK? (2 sec). You/ say.. Iodayn. I say
/Ch: Oh! /SM: OK.
Iodeen. ((Ss comment))/ Yes. ((T and Ss laugh))
/Jeff: Iodeen
Je: That's. uh..Krypton/ ... 4d10.5s2.5p5/ 5p5
/ Krypton / 5s2 . 5p5 OK.
/SF: 5s2 . 5p5
The electron dot notation.. I mentioned.. is the.. outside.
orbital.. uh.. wrong ... is ~~n~~the outside. shell. where. what's
the. outside. shell. here. Ron./ The third. How
/Ro: the third
many electrons in the outside shell? uh. Hilary./ Sh!
/S: seven
Hilary./ Seven. Thank you./
/ I. know. seven. /Ss: Why? Why!/
/SM: Oh. yeah!
The 3 is the shell ... so it's two ... seven. So. we write
this one ... (4 sec) We put 7 electrons/
/SM: 7 dots?
12:37:04 Ron: Does it matter if you put that. or if you put.. two
on the bottom?/
/ You could put.. Yeah. We write them.in
pairs./ ... Because ..-hold it- when we diss- Class! -
/ SM: Oh we do?

When we discuss.. bonding. it'll be important to know.
that they're in pairs. because. they like to have these
opposite spins.. Uh./ but it can be.. the
/SM: They *like* to?
) order is - not necessarily, uh. important. How many electron
in the outermost / uh. shell. *now*. Debra?/ *7*. (13 sec.
/SM: 5 /De: 7
Did you catch that? ((aside to Joan))
What's the outside. shell. Joan ? What's the out. what's the
highest principal quantum number ?/ *4*. 2 electrons here.
/Jo: 4
5 electrons here. Seven. And for Iodayn.. what would it.. *be*:.
uh. *Monique*? / *7*. *Now* ../
419/397 12:38:30 /Mo: 7. /Jeff: I'm getting a pattern.
15) Ah! very good. he's getting a pattern/ What is the
/SM: Aha!
pattern.you are seeing. Jeff? / Sh!
Je: We're seeing that / ... in the.. VII A column..
they seem to. have seven dots./
/ Yes. It says VII A .. let me
get this. uh ((grunt)) ... VII A. and it has in the outside shell ..
seven electrons. Yesterday we did. what family?/
/Je: IA/
/SM: IA
25) The IA.. and how many electrons in *that* outside. shell?
SM: One. SM': Two.
One./ And if we did the IIA. how many
/SM: *One* ((mimic))
electrons would you see?/ And if we did the IIIA??/
/Chorus: *Two*. /Ss: 3.

... Isn't that amazing! ((Ss laughing))/
/SF: It is!

431/410 12:39:20 SM: That's IIIB..((To T))/Tell us about the B's!
/SM': Tell us about the B's!

5) Oh! .. the B's./
/SM: Aha! .. They're different. ((Ss comment))

Alright ... ((waits)). The B's. ... If you wanna ...((waits for quiet)) The B's
have a special name./ Killer - not the Killer
/SM: Killer Bees

B's! ((General laughter)) The B's have a special. name..
which is.. see this large bracket.. transition elements.
What orbital is being filled up for the. B's ? (4 sec)
Ann. please.((to quiet)) Natalie? / the d orbitals.
/Na: the d

5) Those all have. properties very similar to each other ..
and the d suborbits being filled up .. and these are. are
metals. There also. families in here that have similar
characteristics. Take a look for instance at. Copper, Silver,
Gold. (7 sec) ((DB)) Look at the electron orbital. electron
configurations. for copper, silver, and gold. /
/SM: Money!

(15 sec)... What do you.notice. Mark? -Sh!-
/ SM: (   ) copper, silver, and gold Ss: ((Laughter))
about these electron configurations? ... of copper, silver, and gold?

5) Ma: There's..two um... There's .. one in each. one left in
each. /
/One left in each. What does that mean?/
/Ss:((laugh))
SM:dots

Do they look at all similar to you?/ ... Mark?
/ SM: Ssss. Aah!

Ma: No./

/No./

/SM: (We could all have a good time)

Gold has.. uh. Copper.. everybody find copper, element 29?

Copper.. 3d10.4s1..Silver..4d10.5s1...Gold..5d10.6s1.

Ch: You din' say 4f14/

/SM: They got nice s.. they got nice

s-rings.

On the outside shell. the outermost shell. the outermost

electron shell is. similar. They have therefore similar

properties. Copper, gold, and silver are all called. coinage

metals. They are all found free in nature./

((Laughter))

/SM: Free?

SM: ( )/

/Right. What do we mean by. free in nature. Sam?

Sa: Not mixed up with ..uh.uh/ mixed up with

/SM: homogenous ((geenus))

any obher. elements./

/Yes. They are pure. They are found

uncombined./ That wasn't free. Alright.

/SM: This wasn't free.((his ring))

83/458 12:42:26 I brought in here... I brought to class. Chlorine. Bromine.

and Iodayn/ The reason I say that is because.../

/SM':Iodeen /SM: Chlorine

SM: Iodeen

((BELL RINGS)) Oh! / Wait=wait=wait=wait. This is.

/Ss"!Oh. Aww! Aw!

what state of matter?/ Gas. This is what state of

/Ss: Gas!

matter?/ A.liquid.. and iodine we lookdd at before../

/Ss: liquid SF: powder /Ss: Solid!

Solid. Ok. /

/SM: Is that it? SF: Is that. it. is that what you wanted us to see? /

/No. we're gonna talk about the

493/468 12:43:00 properties. We'll look at these tomorrow. ... ((To S)) Well we got tied up here. ... ((Much S talk)) (I) only had 5 more minutes left.((sc. to do))

((General talking))

((END OF TRANSCRIPTION OF 27 NOV 79 Period 6))

12:43:12 Front recorder off.
12:43:57 Back recorder off.

Transcription conventions:

Dialog beginning at a line or at / , is by T.

Dialog by S is marked Na: for name, SM or SF for student-male or female, S if sex undetermined. Ss: mark speech by several students in rapid succession, usually saying the same thing. Chorus: is used when many speak in synch.

n/m for Tape number of front/back recorders

A marginal indication of speaker is used if ambiguity occurs.

(( )) enclose researcher's remarks, usually of audible material on tape, or to clarify context

5) is line number on this page, cited as, e.g. 18:5 .

( ) with blank interior is speech not resolved

(something) is probable resolution of unclear speech

. is used for minimal puase or hesitation (like comma)
.. is used for longer pause, still internal to 'felt unit'
... is used for pause from one to two seconds

(n sec) is used for T pause - no speech - of n seconds

, is also used for end of tone- and breath group with a declarative intonation (followed by capital letter)

? is used for end of tone- and breath- group with questionin rising intonation

! is used for exclamatory utterance. _____ for stress emphasi
= is used when segments are joined as if one word
- is used for sudden breaking off of prosodic contour
' ... ' enclose material which is annotated in margin

DB indicates loud bang of closing door

JR

29 OCT 79 (5)   Episode Transcription: The Giant Cell
JR - 5 - 2s   (11:08:49 - 11:23:19)

CONTEXT: We are about 14 minutes into the 40 minute period. T distributed homeworks and old quizzes, took roll told Ss a few correct answers and described his grading policies. After a flase start (11:08:15 'OK now let's get on with the material at hand.') half a minute ago, deflected by further SQs on assigned work, he now begins the lesson prpoer:

1)(146/134)11:08:49   OK.. Um. There's a movie that was made.. quite a while ago
with Steve McQueen in it about this tiny/ ~~planet/~~- .. thing that
/Sm: planning
m: the great ecscape-   /SM: Ooh! ((S comms))
:   came from another planet. called The Blob/...   And that
is- you probably all saw it. it's been on the four=thirty
movie a million times./   This tiny blob goes
/Y: Scott! /Ss:((laugh))
around. and what it does is it eats people.. and uh. by
0)   the end of the movie this little blob that started out
about. this big/ ..   is big enough so that it's . covering
'drawl'(cute)   /SM: 'Na;w!'
an entire diner. Ok. and there's a couple people trapped
inside. and it's. very dramatic. and finally they freeze
it and send it off to Alaska. That's not what-/
/SM: It's
a one-celled animal. isn't it? /
/T: Well, it's. it's sort
of like a one-celled animal. You don't really know because
0)   they don't tell you./
/Y: Giant con(densed) soup!/SM: They said
that./ Y: Why can't he explain science in a scientific way!
/T: The question is..   can
a one-celled animal. reach the size that this blob did in
the movie. Could a one-celled animal./   be as big as a
/S: No

diner? / Why not? /
/Y: Sure. why not? /SM: They only grow up
to a certain point because they. their insides will grow
up to only a certain point./ SM: Scott threw a paper at
/T: First of all. I don't think(..
SM: Andrew. Andrew (...)/Scomms))
=A SM: The size'll only go up to a certain point 'cause the
insides-/of the paramecium, y'know-../
/((Scomms)) /Y: What about paramecium? /
/T: Andrew.
would you repeat what. you just said?/
/SM: Can't hear 'im!
T: Yeah. that's because you're talking.X(sec)/
/A: Inside the paramecium
will grow- one. size. it'll only. you know../
/Ss:((Comms))
SM: I can't hear 'im./Sm': I can't hear either.
T: OK. What we're trying to figure out. You're on the right
track. Why we couldn't have a huge cell.(3 sec) Doesn't
have to be a paramecium cell or an amoeba. Why couldn't
you have a one-celled animal that was. let's say this big?
What would prevent it? /
/SM: What about uh. this.(you) did
this(...) before (it could get that big).OK? maybe it's
gonna divide. reproduction. /
/T: You're not answering the
question. Why couldn't- the dead cell have existed?
SM: At the point they grow to (...) is divided./
/T: Well why
should they go through the problem of dividing? What I'm

saying is. how come we couldn't just have a cell this big?
Sm: Cause of the cell walls. when they've grown so big (even).
n softly to T — cytoplasm or something (...) the whole thing. (...) You know, something like that.
T: Not quite. (1.5 sec) Yeah. Larry?/
/L: It's got no way
to reproduce itself or something'? (2 sec)/
/T: We're not
really dealing with repr=oduction now. OK? I know that's the
next topic. so it's probably ~~on~~ in your mind. but.. uh.. let's
just look at. a cell that's existed. What problem would
a cell like this. have? (5 sec) Richard? What problems would.
a huge. cell like this have?/ OK. Jill?
/R: I don' know.
'loud' — J: Where would it grow? (3 sec)/ 'Where would it be found?
/T: (Huh?)
T; — Let's just say hypothetically. there. a cell like this
could exist in. in water. OK? What problems would a cell
this big have? (2 sec) Yeah? / Well what could be
/S: Food?
the problem with food?/
/SM: Well.the. one-celled animals
eat. very. small food. and they won't know what to get.
(that's good for them- for) their size./
/T: What? say that
again/
/SM: They can't eat. they/ have to have certain types
of food. You know. wherever they live./
/T: OK. Well let's
say. that if it was a big cell. it should be able to eat.
a lot of things. As a matter of fact if you're big. you

can eat more things than a little thing could eat. You
could eat a bigger variety. (4 sec) What problems would.
would this have? a. huge. living thing like this? (2 seC)
Yeah?/
/~~R~~ SF: What about the cells inside the cells? I mean the
parts inside the cells. You know uh-/ OK. organs
/T: say that-
inside the cell. right? And when it grows. it like. crowds
the other ones. you know. and it'll- I don' know.
T: No. go ahead./ I don't know. quite
/~~R~~ SF: And alright (...)
what you're saying. uh. so. why don't you explain it to me
a little/
SF: /OK. The organs inside the cell. right? as um- as
it grows. you know. it'll like. crowd out the other cells.
fake (now you see).. the other organs and the other organs.
((coughs)) wouldn't do. perform the-. y'know./
/You mean organs or
organelles?/ OK. So in other words there'd be
/~~R~~ SF: Organelles.
so many.organelles that. they wouldn't be able to work. is
that what you're saying?/
/SF: They'd be so big, y'know.
T: Idon- I don- (...) Oh. Yeah. what were you gonna say?
Sm: The cell has gotta be/ it's size to get oxygen. to get
deliberate /Ss((coughs))
the blood. and all this stuff/ ...
/S: So they'll eat ... what abou
Sm: I don' know. If a person's gonna have to be (...)
T: No. there are cells that don't live inside the body.

You saw like. like you see in the paramecium (movie)/
/((comms))
Sm: Well don't they come from plants or something/
/S': No
T: No. Those're animals.
(200) 11:13:36 Well. Let's let's use this analogy./
/Sm: I know. they could
be that size. ~~this~~ there is no reason why not./
/T: No. there is
a definite reason why they couldn't be this size. (1.5 sec)
If you think qbout it.. um don't- .. Well. use this analogy.
Instead of thinking of a large cell. think of a large
group.of people. OK? If we had,a huge crowd of people
(6 sec-W) Today there's a. rally on Wall Street to stop.
nuclear. reactors. OK? There's supposed to be a tremendous
turn=out. of people. Let's say we have this huge crowd
of people./
pseud /Y: We're getting the point. Mister Jorro/
/Ss((laugh))
What problems. would. some of the people face?/
/Sm: Cops!
(4 sec) Yeah Ron? ... Larry!.. c'mon.. I mean I was looking
at you when you did it. Be a little subtle. (3 sec) OK Ron.
R: They'd be all crowded together. and not be able to move.
around. you know./
/T: OK. So say they were comfortable there.
Say that had to stay there for a while. Like this rally's
gonna be there the whole day. What problems would y- people
face? Aside from traveling./ OK.
/SM: They'd get hot.

1) S: People would start to stink!/

/Ss:((laughs)/((comments))

/T: ~~Why?~~ What?

'aside' T:'Frank. siddown' Whad you say. Ron? that was a good-

R: Want me to say it again? / People would start to

/T: Yah.

smell./ There ud be so

/T: Why would they start to smell?

much. odor /SM: Damn near sure! /

T: /See now that was- he gave

sort of a silly answer there. but it turns out that that

would be/one of the problems. ((Laughs end)) The people in

/SM: The heat.

the middle. would be dying from the smell./

5) /Ss:((laughter))

Because all these.. people. all this living material. would

admonish be producing a lot of waste products. Andrew. And if you

have alot of waste produced.. the poor people in the middle.

are stuck./ ... What other problems

/SF: Um they can't get the food.

would these poor slobs in the middle/have?

/Ss:((laughs))/SF: They

can't get the food. they can't get any food./

/T: OK. You have

this huge crowd of people. The hot dog vendors would all

be around the outside..((Ss laugh)) and even if the people

in the mid- middle y'know would give. the guy next to 'em

some money and pass it down. or along/. First of all

((/Scomms))

the money would disappear..((laughs)) but even if it. i t

did reach out here. where the hot dogs (are). by the time
the hot dog got back. nobody likes it cold./

/S: Hey!((Laughs))

Y: (Hey I think they) get the point. Mister Jorro.

T: OK the people in the middle have a problem with getting
food. and they have a po-problem getting rid of their
/wastes..and if the crowd was big enough. they'd have a

/SF: air

problem getting air. The same thing would happen to a huge
cell./ Food can only enter. along the outside

/S: It'd die!

edge./

/Y: So if it has- if it's bigger. then more food should
be able to get in./

/T: It's true that more food. should be
able to get in. but.../

/SF: It can't get into the middle.

T: Right. The outside. the material on the outside of the cell.
would use up the food and the nutrients before the living
material in the center could get it. So the stuff in the
center. would end up dying./

/SM: But the stuff in the middle
would be bigger ((other comments overlap))/

((to SM)) /T: Go ahead

SM: It would be like more proportion. It would be like
bigger. than it was in the other./

/T: Say that-

Y: Can I say it? /
/SM: Like all in the nucleus. and the little
stuff. that's in there. would be bigger. than it was. if
it was in a little cell./
/SM: They'd be to scale.
T: Well it turns out that the organelles are. their
particular size because. they function best at that size.
OK? So they. making them bigger wouldn't really. help
things out./
/Sm: Yeah but like with DNA-/
/Y: If the outside
were. if the outside was this big and the inside was this
big. and it grows to be this big. then its insides would
be this big. It would- it would keep. like if there's a
difference of five inches. it would just doublt. if it
doubles its size. Y'know what I'm trying to say?
T: Uh. that's a good point. The thing that. turns up here.
I didn't want to bring it up because it gets into geometry.
and I don't know if you've had. this in geometry yet.. but.
as the area of- we're talking not about a circle now. we're
appos talking about a sphere. OK? a ball. As the area of a ball..
" as the size of the ball gets bigger. the volume. the space
inside. gets larger a lot faster. than the surface area. OK
" the area along the outside. So that. even though the outisde
area would be getting bigger. maybe. a greater. proportion
of. material in the middle../
/Sm:Yeah but the stuff in the
middle. wouldn't it be bigger also?/ SM': The whole thing
/T: Hm?
would grow./ SM: Like with a person. the outside grows

and so does the inside. So that the cell-/
/R: Mister Jorro.
Why is the cell's size limited? /
/T: OK. (4 sec) Go ahead.
R: Why is the cell's size limited?/
/T: That's what we're
trying to figure out./ Yes.
/Sm: Yeah but Mister Jorro. Like
with a person. I mean like we'll grow and so will the inside.
So with a cell. so if the cell grows big. the insides will
grow big to compensate for the size and-/
/OK. what we're
saying is that. the organelles of the cells don't grow
bigger as the cell grows bigger./
/Sm: But how do you know
that if there's never a cell that size?/
/T: We know it by
deliberate observing. small cells grow. ((coughing, pounding)) cells of
a different size. and you can compare a smaller cell and
a larger cell/ Right. the size
/S: One that's changing in size?
of the nucleus is usually the same. the size of the organelle
are usually the same./
/Sm: But in something like you know
like. if the DNA goes beserk or something like that-
T: But it-. Well let's not get into a whole. type of cell
theory.
(265) 11:19:05 Basically. Robert. to answer your question. the reason the
cell size is limited is because as the cell gets. larger
and larger and larger. the proportions in- the living

1) material in. the very center of the cell. is deprived
of food and oxygen. So a cell can't just become. larger
and larger and larger and-/
/Y: Who says the Blob was one cell?
------ What we're uh.. trying to get at here. someone brought it
up before. is why cell division has to take place. And
one of the reasons it has to take place. is because cells
cannot just grow. indefinitely. So that's. it took a little
while to get around to it. but that's our Aim for today.
'reads' (9 sec-W) "why must cell division... occur.' (7 sec)
And we saw that cell size was limited because as the cell
got larger... the center of the cell had a harder and
harder time getting the things it needs to stay alive.(3 sec)
Y: When the cell divides. does it get any smaller?
15) T: (4 sec-W) Hold on a second. OK? (8 sec-W) So the reason
the cell size is limited.. because as the cell gets larger
(5 sec-W) it becomes harder and harder for the. central
part of the cell to get. the things it needs to stay alive.
(24 sec-W) Y: Mister Jorro./
20) /T: Yeah. hold on... let me just.
finish writing. then I'll get to you. 'It becomes harder
for the center ofthe cell to get the necessary..material.'
(9 sec-W) Materials like food. oxygen.. (6 sec-W) OK. Yes.
Y: When a cell divides. it gets smaller. right? So/
/T: Right
wouldn't it- would not function as well as the perfect
size? Now you're saying that's the perfect size.OK?
T: No. I'm not saying this is the perfect size. What I'm
saying is the cell could never reach. a size this big.
Y: No::. I'm just/proving. you know./ Assume that you've
got the ideal size. /SM: A little one.

1) repeated line

got the ideal size.

T: OK. let's assume there's an ideal size for a cell.

Y: That's the ideal size. Now split it in half. Draw a line
right down the middle./ (2 sec) Now it won't function as
/T: OK
well 'cause it only has half. (2 sec)/
/T: OK. You have a
good point. Now what happens is. after the cell splits
in half.. each of the two halves.. will grow. again.

Y: But how long would that take?/
/T: It depends on the cell.
Some cells take 20 minutes to. to double their size. Some
take. hours. OK? (2 sec) but/
/Sm: That's ~~what he thinks~~ (when you finish).
you're not gonna ~~have to~~ work as fast as usual.right?

T: Well for that twenty minutes. it'd just be growing. OK?

Sm:What? / I know but then
/T: The cell would be growing./
like. like so you'd- the cells in your arm. your arm won't
work as good..(~~so right~~ something like that?)/
/T: Uh.. you're getting a little
too..picky. (4 sec) yeah./
/SF: How come the cell only. only
divides um. during a certain life function?

'to Ss'

T: What do you mean?'Sh! C'mon!'/
/SF: Like.. reproduction.

T: Reproduction is a life function. dealing with cell
division. A cell divides when it reaches a size... that.is.
too big for it to handle everything that's goin' on inside.
When it gets too big the cell divides. to sort of uh. make
~~up for it.~~

1) up for it. its increasing size. (3 sec)

(320/308) 11:23:29 OK. Why would... a cell. want to. have its increased size? Why would it be good. to be. bigger?

. . .

((Lesson continues on the advantages of large size, then on cell division as a way to increase overall size without the problem of limits on individual cell size.))

EL

20 NOV 79 Episode Transcription: Longitudinal Waves (19 mins.)
EL - 8 -2 (1:15:46 - 1:35:05)

CONTEXT: We are 9 minutes into the 40 minute period. T began with the 'frozen goose' story, which he related to his efforts to help students learn, and lectured them on their performance. He then collected old texts from some students, took roll, and now begins the main lesson:

1)(121) 1:15:46 'Yesterday. we were talkin' about.. uh. wave motion. And
we said that sound was a particular kind of wave motion.
'soft' Can anybody remember what kind of wave motion sound is?
D'you remember?' ((S indicates wants pass)) Why should I
give you a pass? (4 sec) ((Ss laugh)) When you can't
answer a question like that? (2 sec) What kind of wave
motion is sound? (2 sec)/
/SM: It's- it's a wave motion.
T: Sound is ~~It's~~ a wave motion. What kind of wave motion?/
0) /SM: Sound
wave./ Vibration.
: /Sound is a wave. what kind of wave? What
kind of vibration?/ What kind of waves?
/SM: Waves(...)
Ss: Sound/waves. /T: M=hmm.
/E: Are you askin' which one of those four?/
'slow' E: Oh.. um.. uh long-.'longitudinal'. wave./
/T: Eugene is
19) correct. ((Ss comment, whistle))
(31 sec) ((T silent, writes))

Jimmy J: Hello there./
'sharp' /T:'No!'.. If you coulda answered this
question I'd a said yes. (2 sec)/
/J: Can I (talk to you?)
: What kinda- it's not a (question of- stay there) ((Ss laugh
nervously)) No. No. /

J: No what? You don:t even know what I was gonna ask you.
(mimics T?) S: 'What was the/answer to the question? ((Ss laugh))
/J: I can't see. /
/T: Tough. T.U.F.F. (2 sec)
When you can be quiet. I can hear you up here. OK?/
/J: (...)
So flunk! That's what you're telling me. OK? Alright.
You'll have to listen very well back there. OK? ((Ss laugh))
Sorry./ That's your problem./
/J: (...) But it's(your)problem
because you won't let me (even hear). /
/T: Right. It's your
problem though. It's your problem. See me after class
and I'll talk to you./ OK? I'll talk to you. (2 sec)
/J: OK.
Because it doesn't ~~matter~~ make any difference where I put you. As of right
now. you have a U. an unsatisfactory. a flunking mark./
/S: Whew!
If you change your way of livin'. you'll pass. but not
end Jimmy right- not the way you've been doin'. Alright?

---

(148) 1:18:09 Now let's look at longitudinal waves. (9 sec) 'Control
'aside' yourself' Alright. Now what. If we take a spring. and we
compress it. as we did here in class. you get a pulse.
to go down the spring .. that looks something like this.
(5.5 sec)/ And so forth going down the spring. (7 sec)
'mocking' /S: Wow.
S: We gotta draw that? /S': No. ~~X~~(sec)/
/T: Now I'm putting this
up for you and not for me. If I put it on the board..
since. you do not have (as) yet a textbook. it's a good

1) idea. to put it in your notes. You don't *have* to. I'm
not making you. You'll. be taking it next term if you
don't get it this term. It's up to you. (13 sec) ((Ss side))
'aside' *Now*. *if*... 'Felicia please.. Felicia' If you compress.
a spring. as you saw in here. what we did. last week. what
we did. before yesterday. If you compress a spring. a
pulse goes down that spring. (2 sec) Now notice that the
spring. does not move. from me to the door. say. if I have
it attached to the door. The spring *is*. between me and
10) the door. But something *does* move. if I push that spring.
something *does* move between me and the door. What moves.
William?/ Alright. a pulse *does* move.
/W: A wave./ S': Awave.
Now notice that the wave motion *goes* to the right. from
me to the door. if I push it in that direction. So the
wave *motion*. is toward the door (2 sec-W)
(170) 1:20:05 Which way does the *spring*. move? (3 sec) Paul?/
/P: The
'soft'to T opposite. / S':'It's not moving.'/ 'It's not moving.'
/T: Huh?
20) T: But it *is*. If you recall that spring. it *did* wiggle.
Which way does the spring move?/ If it
/S: The same way.
didn't *move*. there would be no wave *traveling*./
/P:The opposite
T: The opposite to what?/ It does?
/P: The way the wave goes.
What a- what- which direction is th'*opposite*?/
/P: Goin'
right from the lens./

T: Are you sayin' that the spring moves back this way?
Yes it does. Does it move in any other direction? (4.5 sec)
Alright let's considwr the spring. before anything happens
to it. It's coiled like this. OK? (1.8 sec) Now once I
send a pulse down.. the spring looks like this. (8 sec)
Now which way. did this particular particle here. have
to move. in order to get the thing to stretch?/
/SM: That way.
Alright. Now which. particular direction. in a moment
later. as this pulse travles. this will be the stretched
out part. and this will be the compressed part. (2 sec)
OK? In which direction. does this particle have to move.
in order to. get back over to here?/
/S: It seems it (falls)
this way./
/T: Alright, And if you look at the spring.. if you look
at the spring. you can see that the direction of the
medium. the srping itself.. must be.. which way? Duane.
D: That=a=way.
(190) T: Now let's look at this particle here. This particle
here. becomes. that piece of spring there. Which way did
it have to move?/ OK. This particle
/SM: It goes that way.
here... is going to move over to here. and which way does
that move? / Alright. so that as you as
/SF: Over this way.
you send the wave. down the medium. which way does the
medium move?/ But he said it
/SM: To the right
/SM': (Doesn't it come back off the wall?)

T: moves/ To the left. So which way does
/SM: To the left.
the medium move?/ Alright.
/Ss: Both/ways
/S': toward the middle
So. what we have. is if the wave moves to the right... but
the medium.. moves both the the left and to the right.
(6 sec-W)
(201) 1:22:50 Now makes no difference whehter that medium is.. water.
or steel. or a spring. or air. or solid rock. or anything
else. that. sound is traveling throug. It gets compressed.
like that pulse in the stri- in the spring. and it gets
stretched. That compression wave. travels through the
medium. in a direction that I have drawn here. to the
right. and the medium must move both ways./
/SM: The motion
only moves one way? /
/T: The wave goes down. If it hits a
wall it can bounce back.it's true. It can bounce back.
but in either case. the. medium's. motion. moves in the
same direction. parallel. amd antiparallel.. same and
opposite direction.. parallel to the direction of the wave.
(211) 1:23:42 This is the definition of a longitudinal wave. (2.5 sec)
A longitudinal wave is one in which. two conditions. Tell
me.. what are they? Alright Stew./
/St: The particle- the wave
motion travels the same way as the medium./
/T: OK. Travels.
Wave motion travels. and the medium travels. parallel to
that. That's true. So here we go. A longitudinal wave

(9 sec-W) is defined as (4 sec-W) a wave. in which... the
medium (4 sec-W) moves (3 sec-w) parallel(4 sec-W) to (5 sec)
the (2 sec) wave motion. (2 sec). Or in the direction of
the wave. Let me draw that again. The wave moves to the
right. And the medium moves to the right. and to the left.
(6 sec)

(228) 1:25:09 What kind of a wave is it. when the medium. and the wave.
move. parallel. Tom?/
/(2.5 sec)To: The medium and the wave
move parallel? That's longitudinal./
/T: That's. got it. OK?
--------(bdry by S)
'aside' to SF 'What would ya like?'/ No. If it's
/SF:'Can I use the pass?'
really is an emergency and your gonna die without it. Yes.
otherwise no. It's against my religion. (4 sec) It's against my
religion to give the pass. You can have it Christmas and
Easter./
/SF: I don't need it Christmas and/Easter.
/SF': Christmas?
T: You can go to the bathroom on Christmas and Easter.
SF: I don't/need it on Chistmas and Easter-/T: OK.
/SM: That's along time to wait. you know.((Ss laugh)
T: ... This is a.longitudinal wave.

(236) 1:25:53 Can anybody give me an example of a longitudianl wave?(7 sec)
SM: A wave/that (somebody)
/T: Gary? .. Philips./ What's an example
/P: Wha:at?
of.. a longitudinal wave? (5 sec) Doug. how'bout it?
D:(I think that wave's longitudinal.)/
/T: Example? Alright

Telephone

Mike./ What-   Hm?   Say that
      /M: Uh. a telephone call?   A telephone call.
out loud./
         /M: When you call someone on the telephone.
SM: Good God. ((Ss luagh)) /S: A telephone call(...)
T: What is it that goes through the wire. when you call
somebody?/   OK. Now.. Let-
         /SM: Electricity./Sm': Electricity.
.. that. uh. is not a. longitudinal wave. Uh. sorry about
that. it's uh.- I know you might think that the electricity
goes from my house to yours. It really doesn't. The
electricity goes back and forth. (2 sec) Uh.. you might
not believe this. but the electri- the individual electrons
in a wire. travel slower than you can walk. Give you an
example of that. If I take this piece of pole here. push
on one end of it. (2.5 sec) ((Bang)) What happens to the
other end?/   OK. This is the way
         /SM: It's goin' down.
electricity is. When you punch. and electron in on one
end of the wire.((Bang)) one pops out on the other end. OK?
So this is ((Bang)) the.way the electricity moves through
a wire. But. you might say that this pulse. travels
instantaneously. this is if this pole were hundreds of
miles long. and I pushed one end of it. the other end
would move almost at the same time. Not quite. but almost
at the same time. Electricity is like that. When I
push electrons into one end of a ((Bang)) wire. another
one pops out on the other end. and the pulse pops out.
But. the individual electrons travel slower than you can
walk.. the current travels at the speed of light. So. it's-
it's not a longitudinal wave motion. It's somethin' quite

different.

(264) 1:27:53 Can you give me an example of longitudinal wave motion?
Please. (3 sec) OK?/
/SM: Like when a wave comes in. y'know
on a beach. like just a/(...) wave.. it goes back out.
/T: That's No
that's a water wave. That's traveling in a circle more than.
in a . longitudinal wave. This is- this is not a
longitudinal wave. A water wave is not a longitudinal
wave. It's not quite transverse either. It's.a different
kind of thing. water is. But uh. Can anybody in the room
give me an example of a longitudinal wave? (2.5 sec) Victor.
how 'bout it? (3 sec) What've we been talking about?
V: Water waves? / SM: The spring./ V: Oh.
T: What else? what's the topic?. what're we on?
Ss: Waves/Wave motion/ Sound/ Sound/Wave=sound.
T: Yeah. Who said sound first? / Y'did? Alright Gary
/G: Me.
you're right. It's sound. Sound=wave is a perfect example
of longitudinal wave motion. (10 sec-W)

(278) 1:29:03 Now what we did yesterday was the same sort of thing as
the spring. when we talked about compression of air. Instead
of compressing a spring. let's compress air. instead. and
watch what happens. If you could see molecules of air..
SM: Can you?/
/T: You can't. they're invisible. if you could.
you would see...((making dots)) magnified billions of
times. little dots. Now I'm going to draw a line. so you
can see it. and represent a molecule of air. Alright. now
there's billions and billions on this line. and there's

1) another molecule right beside it. and another one right
beside it. like this. with no sound at=all. Now as soon
as you make a sound. pulse./ 'You with us.
aside' /A: 'Michael.'
Andrew? OK.' As soon as you make a sound pulse. you cause
these air molecules here to move. along. in this direction.
to stretch apart. And to make a compression. here. And
air molecules that were over here. will move sideways. in
this direction. to make a. compression. And as the pulse
10) travels .. it gets compressed again over here.. and then
air molecules stretch apart. They get compressed again.
And they stretch apart. So now notice what happens is
exactly the same thing with a seel- a steel spring. Here
I have a pulse. that causes the spring to stretch togeth-
uh compress together and stretch apart.

(298) 1:30:38 Now. Which way. are these air molecules moving. if the
sound moves to the right? Sound wave.. goes in this
'soft' to S direction. which way does the. air . move? 'Which way?'
SM: Wha-/ S: Left. /S: That=a=way.
'whispers' /T: (6 sec) 'Which way'/'Which way?' /'Well. no it moves
UM(gesture) this way.' ((Ss laugh)) 'Know which way it travels?'
S: left/
22) /T: 'To the le ft' (2 sec) Well now. sound is. a.
uh a wave. Which kind of wave is sound?/
'soft' /SM: 'Longitudinal'
Say it out loud. Say it out loud./
/SM: Longitudinal.
If sound is a longi- longitudinal wave. What's the medium
which carries the sound through air? (2.5 sec)/
/SM: (...)

Say it out loud./
/SM: (...)/S': What?/S'': *Whad* he say?
What's the medium that carries the sound?/
/S_1: Air./S_2:Waves.
S_3: Air?/
/T: Yup. And the air has gotta move. it's gotta
be compressed. if the sound wave is going to travel *through*
it. Which way does the air *move*. if the sound travels..
from the street to the door here? Which way does the
air move?/ (2 sec) If you put that on a test. I'd
/E: (It travels)
say. *Ethel*. I-/ I- I'd still say... no good./
/E: to the right- /SM: You're *wrong*.

T: Now if you didn't listen to what we did before. you
were off in a fog someplace. right? Which way did the
spring move? (2.5 sec)/ When we sent a
/SM: *Away* from you.
pulse through the spring. which way did the *spring* move?
'to M' 'To the right or the left'? / I'm gonna.
/M: to the right.
call it *wrong*. Now look at the board. and tell me *why* it's
wrong. (5 sec)/ I'm gonna call *that* wrong too.
/M: To the left.
Let me see your notes. *please*. You takin' notes now. Fred?
M=Fred M: I don't have a pen. /
/T: 'Yeah. OK.' (2.5 sec) 'Which
'very soft' way does it move?' ((to S))/ 'Yeah. of course.'
/S: Both ways.

T: What we're saying is that air. when it's *still*. must be
compressed. so it's gotta move *in* to the *right* to make the

1) compression. The next instant that pulse travels over here.
so these pieces of molecules. or these molecules here.
have gotta be stretched *apart*.. and form a compression as
that compression moves in this direction. Like the pulse
going through the air. So the air has to alternately move
to the *right*. and then it has to move. *back* to the left. OK?
It moves.. two ways.

1:33:18 Now if the.. pulse moves to the *right*.. and the medium
moves. to the right *and* to the left.. what *kind* of a wave
0) motion. do we *call* this please. Michelle. What kind of
wave motion./ *Sh*.*C'mon* .

/SM: When it moves to the right-

What kind of wave motion *is* this? (2 sec)/

/SM: *I* know the
answer./

/T: Alright. the *wave*. moves to the *right*. OK? the
air moves both right and left. in this kind of wave motion.
What kind of wave motion *is* this? Michelle please. (5 sec)
9) What kind of waves have we been talking about? (2 sec)
'very soft' Mi: 'Sound waves.'/

/T: OK. I won't hit you. Alright- it's
alright. You can say it. It's not a dirty word. 'Is it
'soft' to Mi alright?'/ Israel. what kind of.

/S: (...)/S': Whad he say?

wave is it? when they.. the *air*.. when the *air* and the
medium move *parallel*. what kind of a wave? (3.5 sec) *is* it?
(4 sec) Sandra tell 'im. (3 sec) Gina tell 'im./

/G: *I* don'know.

Alright. OK. Ethel?/

/SM: Hey! that's a longitudinal-

1)'aside' T: 'I'm sorry. excuse me. Eh- I know.' (1.5 sec) Yes. say
it out loud so we can hear you./
/SM: Longitudial ((sic))
T: ((Ss laugh)) He almost had it. What is it. tell 'im.
Ss: long-/longi-/ almost /
/T: Say it out loud so Sandra
can hear you./ Try.
/SM: I can't even say it right. Nah.
/Ss: ((Ss comment)) SF: What he say?
/S: longitudinal
'loud' SM': longitudinal wave/ 'Longitudinal wave.'
/T: Yes. /SF: What?
SM": Y' coulda yeeled a little louder./((Ss comment))
/SM': Sorry.
end episode---------------((Right)).
(358) 1:35:07 Now there's a second kind of a wave. Yes./
(S bdry) /SF: Can I use the
pass now?

. . .

((T relents and gives her the pass. Her requests mark the major boundaries quite accurately. Lesson then takes up transverse waves in a 10 minute major discussion, and ends.))

LC

26 NOV 79
LG-5-1s

Episode Transcription: Terrestrial Radiation (26 mins.)
(11:33:53 - 12:00:00)

CONTEXT: We are about 14 minutes into the 40 minute period. After a few announcements, T did demo on colors of spectrum and introduced idea of electromagnetic radiation. He then asked Ss to relate this back to the unit begun the 1week before, which leads into study of weather thru analysis of earth's response to solar radiation. He got a few extended answers, which he summarized but did not evaluate or build on, writing instead the lesson AIM and beginning it as a new lesson topic:

(144/143)11:33:53 Let's get to the main question for today. and we'll take
what you just said.. and let's talk about.. the earth. We
talked about the sun. reaching the earth. with it's energy.
(2 sec) Let's talk about what happens afterwards today.
(34 sec) ((Twrites at board))
And this says.' What are some factors which affect.
terrestrial. radiation.' (6 sec)
And there are two words in this Aim...that I think we
better make sure we understand first.. so we can go on
from there.. and answer the question I hope. by the end
of the period. (4 sec) What is a factor? (1.5 sec)
What do you think the word factors means here? It can
mean a lot of things. but in this. sense? (2 sec) Yes.
G: It's- it's cert- it's things affected./
/T: What Gary? a
little louder./ O=K. Anybody
/G: It's like. certain things.
else? ~~Bobby?/~~ Tommy?
/B: Does it have to do with like. the subject
you're talking about? /
/T: OK. David?/
/D: The main elements?
T: OK. In other words there are a lotta ways to describe it.
but as long as we understand the key idea.. the things that

have an effect (2.5 sec) Effect. change in something. In
other words what we're really asking is what changes.
terrestrial radiation. Except we didn't figure out what
this word.terrestrial means. Except all of you who watch.
Star Trek and... Planet of the Lost Chicken. and all of
((Ss laugh)) those terrific programs. ~~(slow effects.~~) must know what that means
already. Monica? / Frank.
/M: Um. it refers to the sun and-
did you hear Monica?/ Why not? Aahh. Always
/F: No. She hasn't (...)
bored with a good lesson. Be quiet. ((Ss laugh)) Monica tell
us again/
/M: I asked you if it had to do with the sky or
(celestial) the heavens. /
/T: Mmm. no./ You're setting your sights
/SM: No.
too high. Monica. (4 sec) David./
/D: Something that has
to do with the earth./
/T: The earth. OK.
11:36:32 Nŏw. let's take off our pretty picture here.. and we'll
get started. (5 sec)
And we're gonna use some simple questions to get at some
complicated ideas. First of all. (2.5 sec) And this is.
literally. something I expect you to remember from last
week. so it should be a snap.
(24 sec-W)
And what form of radiant energy do we get from the sun? (sec)
Scott?/ OK. I'm gonna kinda ~~try and~~
/Sc: Sunlight. Sunlight.

capsulize that.. and write down. light.. energy. (8 sec)
Light energy essentially. David?/ OK. That's
/D: Solar energy?
another way of saying light energy from the sun. Yes.
S: Heat. /
/T: Well. I'm not.. yeah. ~~heat or light~~ youre right. But a
very small amount. compared to the light. OK? For example.
you know it's daylight today. because the sky is lighter
than it is at night. not much. because it's pouring out.
But you don't feel any heat from the sun today. (4 sec)
Light energy. essentially. (2 sec)
11:38:18 And now we come to another question. And something people.
I think very few people realize. but now you will. and
maybe you'll tell all your friends. (2 sec) (([illegible] comment))
'aside' to S 'Shows how scientifically oriented you are.' (2 sec)
Let's take this sunlight... And let's look at a little
picture. (5 sec)/ (8 sec -W)
/SM: Um. do we gotta draw this?
That's the earth's surface. This is the inside of the
earth. Here's the sky. And here's... light energy coming
pseud=SC down from the sun. (8 sec-W) Now from what Mister Scott
said last week. What happens. when. this. energy.. hits
= T draws the earth? Charley?/ OK. (16 sec-W)
/Ch: The earth absorbs it? (sec-W)
Erin?/ There's some reflection.
/E: It also reflects it.
(6 sec-W) Let me ask you something. from what Charley.
and Erin told us... what determines. the amount of
absorption. or the amount. of reflection? And I'd like
to make that. the next question. (4 sec-W) Oh! I started

with A. I'd better go to B instead of two. (17 sec- W)
Well. A new hand. Chris./ Partially ~~Partly~~ right.
/Uh. the seasons.
(5 sec) Sc: (Varies) ~~Compared~~ with the (different) color of the object-
object./ /S': What do you mean. yes it does?
/Yes it does.
Sc: Uh.. the light colors reflect light and the darker
colors absorb 'em. And.. if it's a cloudy day. there's
not gonna.. the-. earth's surface isn't gonna be absorbing
that much because. it's-. the clouds are reflecting some
of the light./
/T: Thank you Scott. You hit on a key idea.
(helping T write?) SM: Earth's surface./
/T: Thank you. (12 sec- W)
OK. 'The surface composition.' Is it water we're talking about.
is it land? Is it. open land? is it land covered with a
forest? with a city? (4 sec) And now we come to another
question. (11 sec-W)
Let's say the earth has absorbed this radiation. To a
certain extent. some places more. some places less.
'aside' 'less robert' (26 sec-W)
240/ 11:42:11 What happens to the surface area that absorbs. the light
energy? (8 sec) Rosie./ Yes. Not
/Ro: The ground gets hot.
sometimes- not hot enough. to feel the heat. Sometimes-
SF: What gets hot? /
/T: Rosie. would you repeat that?
Ro: The ground gets hot./
/T: Thank you. Did you hear that.
'loud' Erin? Good. If you weren't. whispering ~~listening~~ to Scott. 'you mighta

1) heard her in the first place.' Thank you. (2 sec)
The ground gets hot sometimes. in fact at the beach in
the summertime. if you walk around barefoot./ pretty tough
/Ro: *Yeah*.
sometimes./ You have to do
/Ro: Yeah. my *feet* get burned!
the dance of thecrazed student sometimes. while you're
running to the blanket from the water. Sometimes. it's
not too hot. it stays pretty cool. Sometimes on a day
10) it (*looks* like it isn't) hot. But *essentially*. we're
talking about. what kind of energy now?/
/Ss: Light. light
Ss: Heat.heat. heat. heat/ SM: Solar energy.
T: Yeah. *originally*. And Rosie?/ *Yeah*.
/Ro: *Heat* energy.
(12 sec-W) ((S comments on Rosie))

The *ground* is now creating *heat* energy./ *from*. the light
/E: Well-((sides))
energy. Erin. you have a question?/
20) /Yeah how can it be
the ground creates the heat energy. if the *sun* creates the
heat energy? /
T: /*Well*. on the *sun*. and *in* the sun. the sun
is creating a tremendous amount of heat energy. But it's
sending most of it's energy here as *light*. Traveling through
space./ No::. Some light
/E: But light is *hot*. light is heat.
is not hot at all. When I turned on these fluorescent lights
today. I haven't roasted yet./
/SM: The bulb has heat. / E:

E: Yeah. but when the/bulb is on you get (...) the bulb gets
/T: And essentially..
hot./
/T: most energy from the sun comes here in the form
of light. and not heat./
/E: So the ground can't be creating
heat./ Because if the ground wasn't dark.. then
/T: Well-
it wouldn't absorb the light. and the light. is heat. so
it's not creating it./
/No. light is not heat. The light is
light energy./
/E: Yeah. and heat is heat energy./Ss:((Laugh))
T: And if you remember back.. to the eighth grade... and you
should've learned a rule. and if you didn't it's OK. we'll
learn itnow./ You can change energy from one
/E: What was it?
form to another.. but you can't create or destroy it. Well
I don't know if that's true anymore either. But... you
can change it. from one form to another. And. that actually
happens. The ground creates heat energy. from the light.
which causes something very interesting. (5 sec) Oy:: ~~ach!~~ Attacked!
Attacked by erasers in my old age! Oy. (38 sec- W)
((Ss talk while T writes))
(283/284) 11:45:40 Now from what I've written in the question. (4 sec)
'aside' to S 'I guess you can see Erin in her riding boots.'
It says ' how does our atmosphere.. become. heated.'
We talked about light from the sun. We talked about.
what happens to the ground. Whta do you think the answer
to this question is? (5 sec) Let's see somebody that didn't
answer yet. Uh:: Oh: .. Ian.

Ian: Yessir./ ((Ss laugh)) What was the question?

/T: Hi! It's

'high pitch' up'there'/

'reads' /I: 'How does our atmosphere become heated?'... Um...

by um... the um. particles get heated by light. (2 sec)

T: Mm=mm./ David. do you wanna help him out?

/I: Don't they?

D: Heat that rises from the ground?/

/T: Thank you. Tell

everybody David./

/D: Heat that rises from the ground.

Myst T: Exactly right. And it's got a special name/./

/SF: Yes?

/SM: A name.

T: A very. very special name. Let me show you something.

/SM: Oh.

SM: What is it? ((to S))

(20 sec- W)

'Heat given off from the ground'./

Norm /SM: Is that the special name?

SF: ((laughs))/

/T: No. we'll get to the special name in a

'aside' minute. (7.5 sec-W) 'Copy this down.' Charley. you had

a question?/

/Ch: Like when you're driving down the street.'n

then you see a funny-/

/T: Can't hear you Charley. You got

to talk much louder for everybody to hear you./

/Ch: When

you're drivin' down the street. and you see ahead of you

that the ground looks wet. and then when you come up to

it it's dry. And you'll see the heat wave going up from

1) the ground- from the/street- that's what- Is *that* it?

/T: *Right*.

: Sometimes we call that a *mirage*./ OK?

/Ro: Oh I've *seen* that. It

looks like. just like a little. *puddle*. /

/((Ss laugh))

T: *Now*./ That's one way.. of actually. *seeing* ..

/S: She's amazing! *crazy*

the heat rising./ Seeing that shimmering sometimes.

Ch? /SM: Right.

in the summertime. off a very hot. surface. Erin we'll

get to your question in a second./ (2.5 sec) The ground.

/E: Alright

does give off. *heat*.. and that's *how* our atmosphere is

15) heated. Let's look at a little picture of this. Uh. actually

I want to make it a *big* picture over there. 'Cause I want

to ask some questions. and then add some extra things.. to

this diagram. Take about a half a page. (6 sec-W) Erin.

I'll get to you. I promise.I won't forget, ~~you.~~ (9 sec-W)

Don't draw it yet. I'll tell you how big to make it.

Frank /.. *walk* all the way around.

/F: Yeah? I've gotta *get* some=

thing./

/T: Thank you Frank. *Now*. (9 sec- W) Here's the

ground. and it could be the ground anywhere. This is the *air*.

'nonpublic' (mimics) SM:.'Could be the air *anywhere*' ((Ss laugh))

T: This is the *air* anywhere ..((Ss laugh)) *over* the ground.

Would you please take. about. one half. a page. Divide it.

this way . And as we answer some questions. we're gonna

add things to this diagram. and we're gonna get to that

name I mentioned a few minutes ago./

SM: Do you want the whole thing to be one page?

T: One *half*. of a page. *Thank* you. (2 sec-W)

high pitch' 'Intruders. *iii!* ' (12 sec-W)

OK. We'll start out... with light energy... coming down.

(5.5 sec-W) What is the ground giving off?/ 'But

/Ss: Heat

'soft' I wanna see a hand' (4 sec) *Ah*. *Yes*. go ahead. (2 sec)

SM: Me? I don' *know* uh-/

/T: Oh you're just waving *Hello*. how

are you- OK. *Ian*./ I can't hear you. Ian./

/Ro: *Heat*? ((Ss laugh))

/IAN: Heat. Heat.

(2 sec) OK. Rosie. don't be a ventriloquist. now. Thank you.

/Ro: (I'm *not*)

/Ss: ((Laugh))

T: (4 sec) And the *heat;* is coming. *from*. the ground.

SM: Should we write this?/

/T: Nah. Please draw just this amount so far.

(31 sec) ((T draws and comes to front board))

354/ 11:50:59 OK. Suppose now. we put in a little bit more of reality. The earth is not a pretty picture like this.. it's a real place. and it's always changing. One of the things that might- .. we might add to this diagram that would be realistic. you *certainly*. should be familiar with today./ (15 sec-W)

'soft'
-public / T retro + public.

/Ss: 'Clouds. Clouds'

Let's draw in the clouds. (12 sec-W) How do you think *clouds* affect this process? *Light's* coming down. *heat's* coming up./ (4 sec) Frank? /

/SM: Respiration /F: Clouds in some areas reflect

the sunlight. and where there aren't clouds. when the
sunlight hits the ground it cools it or somethin'.
T: OK. Vito?/
/V: The cloud absorbs the heat. (1.5) 'The
'louder' cloud absorbs the heat.' (2 sec) (I'm waitin')/
/T: *Perhaps*.
Erin?/
/E: Isn't it- the cloud. uh reflects. twenty five
percent of it?/ of the./ sunlight.
/T: Of *what*? /SM: sunlight
pseud=SC T: Yeah. That's the figure Mister Scott gave to you. about
25%. *it's*.. roughly correct. Yes. it prevents sunlight
from reaching the ground. But there's soemthing else it
does even more. David?/
/D: It prevents. *heat* from leaving
the earth./
T: /*Exactly*! It bottles up the heat. So the heat
comes up here. and you can draw this on your diagram. bumps
into the cloud. and tend to stay. nearer the ground. and
not move off into the upper atmosphere.. and disappear.
It kind of *holds in* the heat. (19 sec- W)
So I wrote. 'help the air. *retain* heat' ,, which means.
what we just. discussed. Holding in. or *retaining*. OK.
308/ 11:53:22 Let's ask ourselves *another* question. (27 sec- W)
Now. can somebody. read this out loud to me? But instead
of. just reading the letters. could they say the whole
words. that these letters represent in chemical symbols.
SF: It should be 'How *does*'/ How do C -
/(3 sec) *No*. There're
two things we're talking about. so I can write 'How do'

SF: Still sounds funny./
/T: Yeah. it may sound funny but
it's right. Jeffry./
/J: 'How do. carbon dioxide. and. water
'reads' vapor. affect this process.' /
/T: OK. Carbon dioxide.. C=O=
two. and water vapor H=two=O. So if you didn't. know this
before.. might be a good idea to write it. (2 sec)
Almost all of us do know it. but just in case. I'll write
it in here. (4.5 sec-W) How do you think they affect
this process? Judging from what a cloud does. and by
the way. what is a cloud?/
/Ss: Water, Water vapor
T: What it's the Greek Chorus again? ((Ss laugh)) What is
a cloud? Erin?/ Exactly. In droplet form.
/E: It's water. vapor and uh-
on little dust particles. (2 sec) How do you think C=O=two
and water vapor affect this process? (4.5 sec)
'high pitch, soft' 'Please.. Ooh..Ooh!' ((T mocks S enthusiasm, waving hands))
Erin. Go ahead./ What?
/E: It reflects it. The water vapor
and the carbon. dioxide reflect the. (first parts) of the
heat./ ~~Well~~ No they reflect the light.
/T: Reflect it where?
/E: ~~and~~ and they reflect the [illegible] Back to the/ ye-
/T: ~~And~~ They reflect ~~it~~ the heat where? /SM: Ground
E: ground. /
/T: Yeah. They keep holding it in. The same thing.
(3 sec) Heat retention. (4.5 sec-W)
422/ 11:55:34 You notice what I'm doing here? And I want everybody to

1) look. I'm taking. an idea. and I'm putting it in different
words. retain... retention. they mean. similar things. So
that now you're imporving your vocabulary a little. OK?

'soft'aside SM: 'Oh thank you'/

/T: Now you can write a thousand page
letter to your friends all about heat retention. ((Ss laugh))
Boy is this the Rosie I used to know in junior high school.
Wow. ((Ss laugh))

28/ 11:55:58 Now we come to that fancy name. Look over here. (4 sec)
10) Two more questions and we'll be ready for the fancy name.
'aside' (6 sec) 'OK'

soft' 11:56:15 'I want you to think now', not about. some abstract ideas...
'soft' not about (4 sec) 'the atmosphere and the earth'.. but
about our lives everyday. And what you see around you in
New York City. especially in big cities like New York.
all the time./ This idea of carbon dioxide. and

/SM: People.

water.in the air. (24 sec-W)

'reads' 'How does the atmosphere receive. carbon dioxide. and
20) water vapor?' Now from Biology. last year. for most of you.
you should remember this. (4 sec) Let's see. who. hasn't
even. opened their mouths all today. (3.5 sec) JoAnn.
(2 sec) Think it out. (3 sec) Take a guess. you can take
an intelligent guess.'cause you're very intelligent.

Jo: From plants?/

/T: Yes.. that's one way. (11 sec-W)

What else? Frank?/ Thank you. (7 sec-W)

/F: From evaporation?

Jeffrey./

/J: It rises and condenses to water vapor.

T: Where does it come from in the first place? Sh!

Ss: The ground. Clouds./Sun

/It's like the

/The sun's

T: Only one person at a time. 'cause we can't understand anything otherwise. Charley./

/Ch: It's like a cycle. It rains. it comes down. and it goes up again./

/T: OK That's evaporation. From plants. (2 sec) Animals too. (2.5 sec) Watch. Look at the board. (2 sec) ((exhales)). C'mon I guess you can't see it over here. (2 sec) That's water vapor.. in my breath. Also some carbon dioxide./

/SM: Also some (...)/((Ss laugh)) odor?)

/T: So we;ve got plants and animals. Evaporation. And.. ((exhales)) Well- (2 sec) let me give you a hint. (2 sec) Tony. how did you get to school this,morning?/

/T: I walked.

OK. Anybody who didn't walk? (1.7 sec) Yeah. How did you get to school Frank?/ Ooh. very fancy.

/F: With a car. ((Ss laugh)

A bus. a car. If I wanted to go to Colorado tomorrow.. I'd get awfully tired walking./

/Ss: Take a plane

/A plane/Take a train.

Have you ever watched at the airport?/

/Ro: The airport? I've seen all that stuff./

/T: I'm not talking about the movie.Rosie.

((Uproarious laughter))

) Have you ever watched an airport in action? the planes

taking off? / What do they leave behind when they

/Ss: Yeah.

take off?/ Thank you. (4 sec)

/SF: Smoke. /((Ss laugh))

Pollution. (5 sec-W) ((Ss continue laughing))

11:59:39 ((BELL))

Hold it. Whoah=whoa=whoa=whoa (you've got time). Wait. Frnak.

Siddown./

/F: (I'm not waitin' in this(...).) ((Ss laugh))

11:59:51 T: Sh. We will continue tomorrow. We're up to question (six).

((End of lesson. T comes up to JL to tell what else he intended to cover inthis lesson but didn't get to today.))

20 MAR 80

SC-5-2

Episode Transcriptions: (1) Fossils and Crustal Movement
(11:13:29 -11:24:00)

(2) Summary statements by SC
(11:26:20, 29:01; 34:05-35:05)

CONTEXT: We are ten minutes into a 40 minute lesson. The first six minutes were spent in seatwork (a Do Now) and class routines. 4 minutes ago T briefly announced an upcoming test and began reviewing with class their answers to the Do Now: a series of definitions of crust, folded strata, tilted strata, faults, and fossils. We begin with the last, which leads into the main lesson, a continuation of the previous day's work, exploring types of evidence for minor crustal movement.

1)(113/100)11:13:29 What about *fossils*. what's a *fossil*? (7 sec)

'reads' SF:'Remains of living organisms that exist in the past.'

T: *OK*. (2 sec) That was very good. Anything that was living
in the past. that we have some type of remains of right now.
(5 sec) ((T has brief non-public exchange with S))
Uh how are these fossils formed. what does it take to be a
Hum? fossil. if you want to be a fossil. what do you have to
have *done* to you?/ Sh. Rosie./
/Ss: Oh! *bones*. /Ro: Bones..
10) Ro: You got to leave your *bones* behind./
/T: That's a *part* of it.
but what has to happen? Richie./
/Ro: Oh! I know-/Ri: Dunno
Chris?/
/Ch: Um the remains have to be compacted. in uh.
under layers of rocks and sand and stuff./
/T: Alright.this-
metaling passwd that's good but we're looking for other words. Charlie?
Ch: Y'have to be buried fast./
0) /T:Alright. *One* is y'have to
be buried fast. What about the other thing? (10 sec)
'soft' ((Soft S comments, joking))'Paula'

1) P: You must have hard parts. and be buried quickly.

T: Alright it's gotta have hard parts and be buried quickly.
Is it likely. that if you're around in a million years.
you might find a fossil of a butterfly?/

/SF: They have uh-

Dont't call out. (2 sec)/

Charlie /Ch: No. an impression yes

T: Why not a- a- / Alright.

/Ch: Because there's no bones in it.

10) It has to have hard parts. A butterfly does not have hard
parts. (2.5 sec)

129) 11:15:01 I'd like to go on with what we were talking about. And we
were talking about fossils. that are used as evidence. that
the earth's crust has been moved. Now what did we say about
these fossils. how do they help us- .. know that uh. the
earth's crust has been moved? Vito./

/V: Like. if y'find.
fish. fossils on top of a mountain. you know that once there
was water., up there in the. land moved or somethin'.

20) T: OK. and what else. besides.. finding fossils at high
elevations of marine. that were marine at one time. Tony?

To: They get transported to different. different areas.
or whatever? These. these things ('re) done by tran- they're
all transported and that's how you know that they're moved?
and they were in that. one area? or- /

/T: OK let's remember
that. it's not the fossils that are actually moved. It's
the earth that's being moved. OK? Monica?/

/M: If you find
the original area. with. um. things that belong on land.

repeated line (or vice versa)

M: or vice versa. in water. if you ~~(pull)~~ (find) the ~~(~~opposite of ~~away from~~ what the environment ~~B)~~ is you know. that it was. just the opposite./

/T: OK. What Monica said is right. but what would be an example of what/ she said?

/SF: What'd she say? you can't hear her.

T: Alright. Sh:: she said. that you might find. fossils. in environments where they originally. they- they definitely didn't come from. the- those environments. So what's an example of this? Scott?/

/Sc: Well in a glacier.. or uh.. an area that was once wa-underneath water or something. and they.. y'know.(or- or-) a bunch of(us) underneath the water-. like that ./

/T: That's.that's. good but it. just. doesn't- uh Paula?/

/P: I think you could use the big dome. and maybe then (there's be ... tion) by intrusion?

T: Well.. I think I'm gettin' off the track. Let me help out a little OK? Just let me help you out a little. Remember I told you that we might find. shallow water fish. fish that are known to be found in s-shallow waters. very low waters.. we find these. fossils in deep.oceans. OK that's when the subsistence- subsidence/happens.

/Sc: Yeah but (then what you have could be a ...) underneath the water. that's what I said./

/T: Ah but I was looking for an example. (2 sec) That was good though. Scott. (2 sec)

11:17:13 Alright you remember. we're up to question three OK? This

is a continuation of yesterday's lesson./ This
/S: Is this the sa-
is the same Answer. right.
(62 sec) ((T writing on board))
Alright our question says 'how can fossils help determine.
'reads' minor changes in the earth's crust.' And the first thing
we said we'll label it A. The first thing we said was
what? (3 sec)/
/Sc: Like if you find uh. fossils underneath.
the ocean. deep in it. you know that. that was once the
crust. where there wasn't water. and then when it. there
once wasn't water there. so that the way you determine that
it wasn't. you know that it wasn't originally. the ocean
that'd be there now./
/Alright. that's gonna be the second
part of our answer. OK? That's very good. that's gonna be
the second part of our answer. We talked about. elevations.
what about elevations? (7 sec) Monica?/
/M: You can tell
whether they were under water. or above water by the fossils.
T: OK- we talked about finding marine fossils. remember we
talked about finding. marine fossils. might have been fish.
or crab or anything like that. We talked about finding these
appos fossils. at high elevations. in high mountains. OK?
(86 sec) ((T writing))
193) 11:20:50 Now let's try and understand this Answer that I gave you
here. It says 'marine fossils. are found in mountains of
high elevation' (3 sec) 'this suggests that the crust has
been uplifted'.. it means the earth. is pushed up. OK? the
earth is pushed up. That's what we mean by uplifting.

Ch: Couldn't the water go down? / V: Yeah!
T: It's *possible* that the water level has gone down but
we believe. OK? we believe. that. the earth has been
uplifted. (2 sec)/ This. this-
/Sc: It's just a theory though.
this is /.. this is *fact*. This is not
/V: It's always a theory
a theory./ This is *fact*. OK? /
/V: It's *fact*?! /Sc: Wait a
minute. it can't be a *fact*. there's no *proof* that the
earth was raised up. unless they took *measurements*.
T: They. measurements have been taken./
/Sc: Measurements
have been/taken?
/T: *Right now*. OK? Now I'm gonna try 'n explain
you something else./
/Ro: How can you prove that that's a *fact*?
T: Im gonna try and tell you what happens. just a second.
Scott. Just listen carefully.
Somebody by the name of.. James Hutton. James Hutton. came
out with. a theory of *uniformitarianism*. Does anyone know
what that means? / Dont call out. Does anyone know
/S: Uniform (...)
what uniformitarianism means? (8 sec)
'soft'((aside to S)) 'Do you wear glasses or anything?/ Alright why don't you
/x: No
sit in that seat over there for today.' (8 sec)
Alright who knows what uniformitarianism is? (4 sec) Erin?
E: When something is put into its own uniform.. uh. *unified*.
I don' know.

Uh not really. not really. Scott?

Sc: One day. when the earth grows in certain positions but it's grown. propoertional on all sides. or it's goin' down on one side so like.. you know what I mean? it's like.all. all different parts of the- are.getting larger. and they take measurements on it- /

/T: No. not really. but uh. you're getting' closer. Monica?/

/M: The fishes that are existing one place, say ten thousand . feet. or- if another place is 10 thousand feet and it's under water. then you know that. place is uplifted./ The second place is-

/T: OK. What Monica is trying to say. in one sentence is. what James Hutton tried to prove was (3 sec) The present is the key to the past. OK? We look at things. things that are happening today. happened exactly the same in the past. And- (3 sec) things that happen today. and.. things that are operating today.. happened, in the. the same ways in the past. So the present. is the key to the past. So by looking. by looking at geologic formations. we can tell. if things were uplifted. uplifted. or things subsided. OK just by looking at them. And that's how. that's how there's ways. in which they prove. that things were uplifted. how can they tell they were uplifted.

232/ 11:24:00 Alright. let's go on. to our question. (2 sec)

Uh. we said uh high elevations. OK finding marine fossils at high elevations. (2 sec)

What else about marine fossils help prove. help us prove that there's been changes. besides uplifting ?

KF

15 APR 80

KF-4-1m

Episode Transcriptions: Oxidizing and Reducing Agents

(10:22:47 - 10:35:05)

CONTEXT:

We are 10 minutes into a 40 minute lesson. T called class to order and put up 2 seatwork problems asking for analysis of two redox reactions. After 5 minutes he asked 2 students to write their solutions on the board. As they did others continued working or talked. T now calls on the first student to review the steps of the solution for the reaction $Na + O_2 \longrightarrow Na_2O$ (as given, unbalanced):

1) (106/100)

10:22:47 The uh.. alright c'mon let's get-/ (4 sec) Now we won't

/Ss: Sh! ((Ss continue

be doing. uh. this type of work... ah. much longer. We're

((to whisper and talk in low voices for the first 2 minutes))

moving on to a new topic. (2.5 sec)

So let's review the.steps. What was the first step that

you took. Smiley? / What

/S: ((uproarious laughter)) (5.5 sec)

was the first step that (...)

10) /SM: Smiley! ((laughs, comments cont.))

Sm: Well for the first question I looked up oxidation

numbers. uh for the N=A. which is zero. because it's a

free element.. and O=2 which is zero also. because-/

/T: Fine.

Sm: and then. in N=A two O. the oxidations numbers were.. for

the. sodium was plus one.. and oxygen to equal hydrogen. is

minus two./ OK. And

/T: OK that's step number one. Next step?

Sm: then uh. since. since sodium uh. gained/an .. it lost

0) /S: it lost

uh. the electron. the- I called it.. it was the/ oxidation

/Ss:(laughs))

Sm: /(7.5 sec) the xoidation half=reaction

/ T: Yah. /S: It should be N=A two

1) OK... uh... now.. How did you know it lost electrons? How did you notice that it's minus an electron here ? ~~(that quantitiy))~~/

/Sm: Because it gained. it gained uh. it gained an (in?) oxidation number.

T: Yes. I mean. the clue is here. There's where you. spot (often) what is taking place. /

/SF: Where did you get. the negative four e from?/

/T: say that again

the negative- plus

10) four electrons/

/T: plus- He hasn't gotten to that yet. He hasn't gotten there yet. /Go ahead O=kay- /

SF:/ ↓

/Sm: Oxygen gained two elec-/ it lost it. It gained

/S: no /SF: No. it gained it.

four electrons./

/T: Look. we know it gained electrons. because it went from zero downwards. (it went) downwards in charge. Now the question is why. why not two. why four? where did

'soft' the four come from? 'That's the question'/

21) /SF: Since oxygen is a diatomic element. then it. um. would have to be times it. the. um. two by two. and you get four. electrons./

/T: Yes. Uh. don't be tricked by the. little two that's here. If you want to (on) this side. handle it as if it were just a straight added form. the neutral. becoming the oxide.. ion., alone. How many electrons would it take just to do that job? (4 sec) However. because it comes to us. fixed. as. pairs ~~(a gas)~~.. already in his mind. he's already thought ahead

and doubled it. He doubled it here.. two oxides. and *that's*
where the four came from. He multiplied *this* two. by four.
So.. (4 sec) Next. uh step. after the next is?

soft' Sm: 'Alright' So now y' have four N=A plus O=two. equals
aside to S' to the four N=A=O plus. two O. And then uh (3 sec) 'Yah.'

/S:(...)

then. I just wrote four N=A plus O=two/

/T: ~~Pardon me~~ what made you, . What.
what's the point here? *Why* this four?/

/Sm: So I could-

/S: So that
you can get it to minus four electrons and it'll cancel.
We want these electrons so we can cancel out. *That's*.. the
inner mechanism of this whole procedure. The electrons
must be balanced. And. here we get the net ionic equation.
We should show it as ions. (2 sec) (just the way they are)
and then these. materials come out to us as this compound.
so there's the balanced. reaction.

(151/145) 10:26:55 SF: Um. Didn't- he didn't write the. oxidation agent or the
reduction agent. /

/T: Good. Good. Now we'll get to something
we haven't touched upon but you read for homework/

/S: Oh boy
What is the *agents*. You have correctly stated. the type of
reaction. but haven't correct- you *haven't* stated. the
agents. (2 sec) I know *you* know it. let's have someone
else./

/SF: The oxidizing agent. is O=two. *oxygen*.
Why? It makes sense. from. an *English* point of view. but.
why is this. correctly. the oxidizing agent? How do you

spot the *agent*? /

/SM: Um.. it's it's the uh element. that

choice set! made the *other*. the other um. compound? not compound. it's the element that made the other element. *give* up and become oxidized./

/T: Good. (Dena?)/

/SF: Ah!.. Plus. it has *plus* four electrons. You're adding four to it?/

/T: Well. if we'r~~e~~adding four *to* it. we understand that's a reduction *step*. but. uh. this by itself. we're getting clear what happens to it. this by itself is called the *agent*. for (a very good) *reason*./

/SF: The oxidizing agent is always the one that's been reduced./

/T: That's true *also*. the oxidizing agent *itself* is getting *reduced*. but the reason we call it the *agent* of oxidation is the same reason that

FAM we talk about any *other* agent. the insurance agent.. the

HUM demolition agent.. the *CIA* agent./ *There*fore

/SM: More. more more!

the agent is the material. or the person. that allows something else to take place. This oxygen is *allowing*.. the sodium to go through this step. (2 sec) So let's make note of that fact. underneath. these two. (17 sec-W)

eads 'The oxidizing agent' which in this case ~~is~~ the oxygen. (5 sec- W) The reason we call it that. is *that* oxygen. *allows* the. other step to take place. (5 sec-W) 'enables' (19 sec- W) And *how* does it allow it? What is the oxygen *doing*.. to *anable*. the *top* reaction to take place?

1) SM: It's gaining four electrons./

/T: It's. it's at least

it's gaining the electrons. and thereby allowing this one to

reads' lose. OK? So therefore. we continue the sentence...'by'...

" uh'removing electrons' (13 sec -W) 'but itself'. the agent

itself. since it is removing them and takes them to itself.

what happens to the oxidizing agent itself? It goes down

an oxidation step. (24 sec- W)

(199/193) 10:31:03 OK. Uh. in this uh. analysis. which material is the

10) reducing agent? / Because? (4 sec)

/SF: Sodium /SF': Sodium It's

F' gaining electrons?/

/T: Yes. but that's (it isn't uh) ((writes))

(7 sec-W) Why should we bother to call the sodium. the

agent. of reduction?/

/SF: Because it's being oxidized?

Yah. that is true. but that's not the reason we call it

the reducing agent. Why do we call it. the reducing agent?

SF: Because it's enabling the oxygen to be reduced./

0) /T: Correct.

How is it doing that?/

/SF: by ..giving. It's taking electrons

/Ss: gaining

away./(5 sec)

/Ss: ((comments)) SF: It's giving up./

/T: It's giving up

electrons. (3 sec)

(212/205) 10:32:05 Uh. so. will someone now... re.formulate those two questions.

for the reducing agent. Think it through now. (4 sec)

Speak it clearly because the rest of the students are going

to be writing ~~down~~ your words of wisdom./
/SM: Aw-oh!
'soft aside' (10 sec) 'Alright. Andrea (...)' Alright. Andrea. Loud and
clear./
/A: The reducing.. the reduction agent. enables the.
reduction half=reactions to occur by gaining. electrons/
/S: Losing
T: (4 sec) What about the next step? /
/A: The reducing agent is.
itself. oxidized./
/OK. Would you say the whole thing again.
loud and clear so everyone can/copy.
/A: The re- The reducing
agent enables the reduction-/ The reducing
/T: Slowly. slowly
agent. enables the reduction. half=reactions. to o-uh.occur.
And by-/ ---(10 sec)------- gaining
/SM: Wait wait wait. Hold on. The yeah?
electrons./
/Ss: No.((comments))/
/T: Well.uh. uh it depends on
how you (want to) define the sentence. It itself is losing.
that's how it does it.. so it's by losing these electrons
that it enables the oxygen to be reduced. By losing electrons.
Go ahead./
/A: The reduction agent is itself. oxidized.
Any questions on that?/
/SF: Can she repeat it one more time?/
/Ss:((laughs)
T: Yes (please will you) repeat it./

1) A: The.reducing agent. enables the. reduction half=reactions.
to occur. by. losing electrons. (3 sec)/
/SM: No gaining.

SF: gaining SF': I thought it was 'gaining'
T: Well no. it depends upon what you want- ... We're
talking about the agent itself. the reducing agent. how
does it do the job? It does the job. by losing it's own.
Yes?/

/SF: But it enables. the oxidation. the um. reduction
half=reactions to occur. because they gain. electrons.
'concessive' T:'You're right. You're right' She was right to begin with.
(2 sec) Say it again./
/A: The
/SF': The reducing agent. the uh
A: reducing agent enables / the reduction half=
/Ss: Sh! Sh!
reactions to occur. by gaining electrons./ The
/SM: Wrong!
A: second one is this. the reducing agent is itself oxidized.
(3 sec)

10:35:05 T: Now let's look at this one here.

(Lesson continues as T goes quickly over the second
reaction worked out by another S on the board. He then
makes a transition to the new topic, electrochemistry.)